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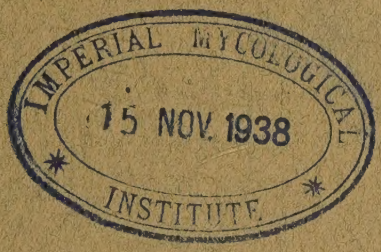

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LIFE HISTORY AND HABITS OF THE COTTON BOLLWORMS IN THE PHILIPPINES WITH SUGGESTIONS FOR THEIR CONTROL[1]

By FILOMENO L. BUTAC

Of the Plant Pest and Disease Control Division
Bureau of Plant Industry, Manila

FOUR PLATES

Of all the insect pests of cotton, those that attack the squares and bolls are undoubtedly the most destructive. Of these, the one that has been studied to some extent by Woodworth (1922) and Otanes and Butac (1935) is the local cotton boll weevil, *Amorphoidea lata* Motsch. So far, however, very little is known in the Philippines about the caterpillars that attack the bolls, of which there are at least three species. Accordingly, it was deemed advisable to put together all local data available so far on these species.

Most of the data presented here deal mostly with the life history and habits of one of the species, namely, the spotted bollworm, *Earias fabia* Stoll., of the family Arctiidae. However, data on the life history and habits of another species, *Earias chromataria* Wlk., of the same family and those on the pink

[1] This study was conducted at Singalong, Manila, under Dr. Gonzalo Merino and Mr. Faustino Q. Otanes, Chief and Assistant Chief, respectively, of the Plant Pest and Disease Control Division. To them the author is very grateful for kindly reading and criticizing the manuscript.

bollworm *Pectinophora gossypiella* Saund., of the family *Gelechiidæ*, are also included.[2]

METHODS OF STUDY

Larvæ or caterpillars of *Earias fabia* collected from the field were confined individually in test tubes and each was supplied with food consisting of the top portions of healthy branches of cotton cut long enough to be accommodated conveniently in the test tubes. At times, young bolls were used instead of the shoots. These individual caterpillars were allowed to pupate. When the adults emerged, a male and a female were confined together in a breeding jar where the female was allowed to lay eggs on the fresh tip of a cotton branch provided for the purpose. Underneath the cheese cloth which covers the breeding jar, a ball of cotton, wet with dilute sugar solution for the adults to feed on, was suspended.

The eggs laid in a night were isolated by simply transferring the pair of adults or parents to another battery jar. When the eggs in each jar were hatched, some of the tiny caterpillars were confined individually in test tubes, each provided with tops of cotton for food, as in the case of the caterpillars collected from the field. The changes in the development of the insects were observed everyday.

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The eggs (Plate 1, fig. 10).—The eggs are small, almost round, about 0.4 millimeter in diameter, green, reticulated, with projections, or protuberances, at one pole. The incubation period ranged from 2 to 4 days with an average of 3.4 days under room temperatures, ranging from 23.3 to 30.6° C with a mean of 28.2° C, and relative humidities of from 56 to 76.7 per cent (Table 1)[3], with a mean of 67.6 per cent.

Larval stage (Plate 1, fig. 4).—The newly hatched larva is about 2 millimeters long, the head being darker in color than the rest of the body, which is light brown. The full-grown larva is about 16 millimeters long, of a purple color, and with

[2] Most of the field observations in this work were carried on in the cotton cultures used for breeding purposes by the Plant Breeding Section, at Singalong, Manila.

[3] Temperature and relative humidity were computed from every two-hour reading each day. The hygrothermograph was placed in the laboratory near the breeding work.

TABLE 1.—*Life history of Earias fabia in the laboratory with the corresponding temperature and relative humidity for each stage from January 10, to May 15, 1935 and January 27 to May 1, 1936.*

Stages	Duration	Temperature	Relative humidity
Incubation period of eggs (71 cultures):	*Days*	*°C.*	*Per cent*
Maximum	4	30.6	76.7
Minimum	2	23.3	56.0
Average	3.4	28.2	67.6
Larval stage (30 cultures):			
Maximum	17	31.6	82.8
Minimum	11	21.2	54.5
Average	13.6	31.8	68.1
Pupal stage (35 cultures):			
Maximum	11	32.0	82.6
Minimum	8	25.6	54.4
Average	9	27.8	67.8
Emergence of adult to first oviposition (9 females):			
Maximum	5	30.7	79.4
Minimum	2	23.4	58.4
Average	3.4	29.3	69.1
Life cycle-egg to egg:			
Maximum	37	32.0	82.8
Minimum	23	21.2	54.4
Average	29.4	29.3	68.2
Longevity of adults (15 individuals of males and females together):			
Maximum	28	31.5	79.8
Minimum	3	21.2	54.5
Average	17.5	28.6	67.0

white spots on the back. Because of these white spots the caterpillar has been called "the spotted bollworm" in India. Both lateral sides and portions of the back near the head and near the caudal end are tinged with orange. The dorsal and lateral sides of the larva are provided with short strong hairs, or setæ; hence the caterpillar is sometimes called "spiny bollworm."

Table 1 shows the summary of data on the duration of the larval stage in the laboratory to be from 11 to 17 days, with an average of 13.6 days, under room temperatures ranging from 21.2 to 31.6° C, with a mean of 31.8° C, and relative humidities varying from 54.5 to 82.8 per cent, with a mean of 68.1 per cent.

The larvæ were observed to appear in the cotton fields before the plants were in bloom. At this stage of the growth of the plants, the larvæ bored into the stems and branches of the young plants from the buds, thus destroying the main

shoots and branches, which are potential producers of flowers or bolls (Plate 2, figs. 1 and 2). Between 9 o'clock in the morning and midday they were observed to wander from branch to branch in search of new ones to bore into. However, when flower buds, flowers, and bolls were already present, the caterpillars showed a decided preference for these; hence the name "bollworm."

The caterpillars hollow out the flower bud or otherwise eat all the contents. If it is an open flower that is attacked, they simply destroy the anther and then leave it in preference for the bolls. A very good indication of the presence of larvæ in bolls is the continuous discharge through the entrance hole of fresh excrement which may be seen projecting out from the side of an infested boll. The exit holes are located at the bases of the infested bolls (Plate 3, fig. 5). Once the larvæ are inside the bolls, they destroy one seed after another, and incidentally, damage the lint.

Pupal stage (Plate 1, fig. 7).—When the larva is ready to pupate, it comes out of the boll to spin a cocoon. It takes the larva about a day to complete the process. During this period it ceases to eat. The cocoon which encloses the pupa is boat-shaped, and the color varies from faint yellow to light brown. It is attached to either the petioles and branches of the plant or to the bracts of the bolls. The cocoon is small, measuring about 9 millimeters long and about 4 millimeters at its greatest width. The anterior end of the cocoon is loosely woven, which condition facilitates the emergence of the moth.

The pupal stage, under room temperatures ranging from 25.6 to 32° C, with a mean of 27.8°, C and relative humidities varying from 54.4 to 82.6 per cent, with a mean of 67.8 per cent, was found to be from 8 to 11 days, giving an average of 9 days (Table 1).

Adult stage (Plate 1, fig. 1).—The adult female is about 8 millimeters long from the tip of the head to the tip of the abdomen, and the wing expanse is about 20 millimeters. The antennæ are covered by the wings most of the time when the moth is in its natural resting position. The fore wing, pinkish yellow with a longitudinal triangular green streak in the middle, is fringed; hind wing, faint yellow and fringed; head greenish white, same with thorax except central part being greenish. The palpi, antennæ, legs, and abdomen are yellowish. The male adult is about the size of the female and is similar in appearance.

The insects are nocturnal. The females were observed to lay eggs only during the night, the eggs being laid singly on or near the terminal buds, and sometimes on bolls and flowers. In the laboratory at Singalong, Manila (Table 1), females were found to lay eggs in from 2 to 5 days (or with an average of 3.4 days) after emergence. The periods of fecundity (Table 2) varied from 8 to 22 days with an average of 13.3 days. The average number of eggs laid daily by a female (Table 2) ranged from 1 to 73 with an average of 19 eggs. The total number of eggs laid ranged from 91 to 327 eggs or with an average of 239 (Table 2).

Under room temperatures ranging from 21.2 to 32° C and relative humidities varying from 54.4 to 82.8 per cent, the life history of the insect in Manila, as shown in Table 1, from the time the eggs are laid to the time the adults begin to lay eggs, was from 23 to 37 days, the mean being 29.4 days. The corresponding mean laboratory temperature and relative humidity were 29.3° C and 68.2 per cent, respectively.

TABLE 2.—*Data on the reproduction of Earias fabia in the laboratory from January 10 to May 15, 1935 and January 20 to May 1, 1936.*

	Duration Days
Period of fecundity (4 females):	
Maximum	22
Minimum	8
Average	13.3
Number of eggs laid daily by a female (4 individuals):	
Maximum	73
Minimum	1
Average	19.4
Total number of eggs laid by a female during period of fecundity (4 individuals):	
Maximum	327
Minimum	91
Average	239.8

Under laboratory temperatures ranging from 21.2 to 31.5° C, with a mean of 28.6° C, the adults were found to live from 3 to 28 days in confinement or an average of 17.5 days. The corresponding relative humidities were from 54.5 to 79.8 per cent (Table 1), with a mean of 67 per cent.

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Eggs.—The eggs are small, almost round, about 0.4 millimeter in diameter, green, reticulated, and with projections, or

protuberances, at one pole like those of the eggs of *E. fabia*. The incubation period is about 4 days under room temperatures of 28.3 to 30.5° C, with a mean of 29.2° C, and relative humidities of 59.4 to 69.6 per cent (Table 3), with a mean of 65.4 per cent.

TABLE 3.—*Life history of Earias chromataria in the laboratory with the corresponding temperature and relative humidity for each stage from January 15 to May 5, 1936.*

Stages	Duration	Temperature	Relative humidity
	Days	*°C.*	*Per cent*
Incubation period of eggs (16 cultures):			
Maximum	4	30.5	69.6
Minimum	4	28.3	59.4
Average	4.0	29.2	65.4
Larval stage (3 cultures):			
Maximum	21	31.5	76.3
Minimum	20	28.6	56.8
Average	20.7	30.0	65.1
Pupal stage (5 cultures):			
Maximum	12	31.5	87.8
Minimum	7	25.8	56.8
Average	10.0	28.2	70.5
Life cycle–Egg to emergence of adult:			
Maximum	37	31.5	87.8
Minimum	31	25.8	56.8
Average	34.7	29.1	67.0
Longevity of adults (3 individuals):			
Maximum	26	32.6	78.0
Minimum	15	26.9	64.6
Average	20.7	28.1	71.2

Larval stage (Plate 1, fig. 5).—The newly hatched larva is about 2 millimeters long, the head being darker than the rest of the body, which is light brown. The full-grown larva is light gray, about 16 millimeters long and the back is spotted with dull white. The dorsal and lateral sides of the larva are provided with short strong hairs, or setæ, like those of the larva of *E. fabia*.

Table 3 shows the summary of data on the duration of the larval stage in the laboratory under temperatures varying from 28.6 to 31.5°C, with a mean of 30°C, and relative humidities ranging from 56.8 to 76.3 per cent, with a mean of 65.1 per cent. Under these conditions, records on the duration of the larval stage were from 20 to 21 days, the average being 20.7 days.

The caterpillars bore into the stems and branches of the young cotton plants from the buds. After they have consumed the soft portions, they transfer to other shoots or branches. But like the caterpillars of *E. fabia*, they show a decided preference for the flower buds, flowers, and bolls.

The caterpillars hollow out the flower bud, or otherwise, eat all the contents. If they happen to attack an open flower, they

simply destroy the anther. When caterpillars are inside the bolls, they feed on the seeds, and in so doing they incidentally cut the lints. The presence of caterpillars in bolls can be detected by the fresh excrement projecting out from the side of the bolls near the entrance hole.

Pupal stage.—When the larva is ready to pupate, it comes out of the boll, begins to spin its cocoon, which lasts for a day. The cocoon is boat-shaped, like that of the cocoon of *E. fabia,* and is attached to either the petioles and branches of the plant or to the bracts. The color is light brown. The cocoon measures about 9 millimeters long and about 4 millimeters at its greatest width.

As shown in Table 3 the pupal stage is from 7 to 12 days, the mean, or average, being 10 days. The room temperatures and relative humidities under which these records were obtained were from 25.8 to 31.5°C, and from 56.8 to 87.8 per cent, the corresponding averages, being 28.2° C and 70.5 per cent, respectively.

Adult stage (Plate 1, fig. 2).—The adult female is about 7 millimeters long from the tip of the head to the tip of the abdomen. The wing expanse is about 17 millimeters. The fore wing is blue green with reddish-brown spots and is fringed with purplish brown. The base of the costa is reddish. The head is yellowish green and tinged with red; base of antennæ, reddish. The legs are tinged with red, although generally they are greenish white. The abdomen is also greenish white. The male is about the size of the female, and the color pattern is more or less the same.

The insects are nocturnal. The female was observed to lay eggs singly on or near the terminal buds and sometimes on the bolls and flowers of cotton.

The life of the insect under laboratory conditions in Manila, from the time the eggs were laid to the time when the adults began to emerge, under temperatures ranging from 25.8 to 31.5°C, with a mean of 29.1°C, and relative humidities varying from 56.8 to 87.8 per cent, with a mean of 67 per cent, was from 31 to 37 days, the mean being 34.7 days (Table 3).

The longevity of adults was from 15 to 26 days, with an average of 20.7 days, under room temperatures ranging from 26.9 to 32.6°C, and relative humidities varying from 64.6 to 78 per cent (Table 3). The corresponding averages were 28.1°C and 71.2 per cent respectively.

LIFE HISTORY, HABITS, AND DESCRIPTIONS OF THE PINK BOLLWORM (PECTINOPHORA GOSSYPIELLA SAUND.)

Eggs (Plate 1, fig. 8).—The eggs are small, elliptical, about 0.5 millimeter long and 0.3 millimeter wide, pearly white and are finely reticulated. About a day before hatching, the eggs turn faint orange with a distinct darker shade at one end, indicating the head of the developing embryo.

The incubation period ranged from 4 to 6 days, the mean being 4.7 days, under room temperatures ranging from 26.4 to 31.9°C, with a mean of 29.8°C, and relative humidities varying from 58.1 to 91.8 per cent, with a mean of 73.2 per cent (Table 4).

TABLE 4.—*Life history of Pectinophora gossypiella in the laboratory with the corresponding temperature and relative humidity for each stage from March 11 to June 28, 1935.*

Stages	Duration	Temperature	Relative humidity
	Days	*°C.*	*Per cent*
Incubation period of eggs (28 cultures):			
Maximum	6	31.9	91.8
Minimum	4	26.4	58.1
Average	4.7	29.8	73.2
Larval stage (13 cultures):			
Maximum	25	35.1	91.8
Minimum	14	26.4	54.4
Average	16.8	29.9	70.4
Pupal stage (19 cultures):			
Maximum	9	32.3	82.6
Minimum	5	27.8	54.4
Average	6.6	30.3	67.4
Emergence of adult to first oviposition (6 cultures):			
Maximum	7	31.9	82.6
Minimum	2	28.9	58.1
Average	2.8	30.6	71.6
Life cycle—egg to egg:			
Maximum	47	35.1	91.8
Minimum	25	26.4	54.4
Average	30.9	30.2	70.6
Longevity of adult (9 cultures):			
Maximum	25	32.3	91.8
Minimum	7	26.4	55.5
Average	14.8	30.4	73.8

Larval stage (Plate 1, fig. 6).—The newly hatched caterpillar is about 1 millimeter long, yellowish, and with a dark-brown head. As the larva grows, it becomes pink in color, hence the name, and the weak pale-yellow hairs, or setæ, scattered all over the body become more prominent. A full-grown larva measures, about 1.2 centimeters long and 2.5 millimeters wide.

Table 4 shows the summary of data on the duration of the larval stage. It ranged from 14 to 25 days, the average being 16.8 days. These records were obtained under room tempera-

tures ranging from 26.4 to 35.1°C, with a mean of 29.9°C, and relative humidities varying from 54.4 to 91.8 per cent, with a mean of 70.4 per cent.

The newly hatched larvæ were observed to feed temporarily on buds or flowers, transferring later to the bolls that offer abundant food for them (Plate 3, fig. 2). They remain in the bolls to pupate. Before pupation, they were observed to make exit holes for the adults. Infested bolls mature abnormally and the lint is short, colored, and kinky, and the seeds (Plate 4, fig. 2) are of poor quality.

It was also observed that some of the larvæ picked up with the crop during harvest enclosed themselves by fastening together two hollow seeds (Plate 4, fig. 1). These are the larvæ that will pass thru a period of aestivation, the longest period observed so far in the Entomology laboratory at Singalong, Manila, being about 5 months and 11 days. In Egypt, according to Hunter (1918) and Bedford (1923), the larvæ may continue to be inactive in cotton seeds for two years or longer. As was observed in Manila in 1935, larvæ in cotton bolls are not destroyed during the ginning process. Therefore, when the seeds for the next planting season are stored, the larvæ are stored with them, these emerging later when conditions are favorable. In this connection, the following observations by Richard (1924) are worthy of note:

> Most of the long-cycle larvæ pass through the ginning process uninjured, and remain dormant until, at the next sowing time, they are sown in the fields along with the sound seed. As soon as the humidity is sufficient they come out of their silk-lined chambers pupate within the tunnel and ultimately, in the course of a few days, emerge from it to await the opportunity afforded by buds and flowers for the all-important purpose of ensuring the continuance of their race, with the incidental cost to the cultivators of few crores of rupees.

While some of the larvæ of the later generation go to a state of aestivation, there are those that continue their life cycle by breeding on wild cotton and on the cotton plants left in the field. On several occasions during the off season for cotton in 1936 in the Central Experiment Station, Singalong, Manila, the author collected larvæ and pupæ of the insect from *Gossypium arborium* of the jayawant variety as well as from cotton plants left growing in the field during the time. So it could be readily seen that there are two sources of infestation

for each year's crop; namely, from adults that emerge from larvæ that aestivate, and from those that develop from volunteer plants and from those left in the field. Infestations may also come from perennial varieties of cotton plants.

Pupal stage (Plate 1, fig. 9).—Pupation takes place inside the boll as has already been pointed out. The pupa is orange to reddish brown in color, turning conspicuously darker about a day before the moth emerges. It is rather densely covered with short setæ, some of those at the anal end being distinctly longer and larger and are hooked at the ends. The length and diameter are about 9 and 3.8 millimeters, respectively.

The pupal stage (Table 4) under room temperatures varying from 27.8 to 32.3° C, with a mean of 30.3° C, and relative humidities ranging from 54.4 to 82.6 per cent, with a mean of 67.4 per cent, was from 5 to 9 days with an average of 6.6 days.

Adult stage (Plate 1, fig. 3).—The female moth is small and slender. It is about 7 millimeters long from the tip of the head to that of the abdomen and the wing expanse is about 15 millimeters. The color is gray to somewhat dark brown. The fore wings are rather sharp-pointed and are fringed along the apical margins. The hind wings are somewhat broader and are ending in even sharper point than the fore wings. They are fringed both along the apical and anal margins. The male moth is about the size of the female and is of the same appearance.

In the laboratory, the female was observed to lay eggs during the night. The eggs were found laid on various parts of the plant as on the bolls, squares, flower buds, and underneath the leaves when portions of the branches of the plant containing these parts were introduced in the breeding jar. Both sexes were inactive during the day, they being observed to hide most of the time between the particles of soil placed in the bottom of the breeding jar.

In the laboratory at Singalong, Manila (Table 4), females were found to lay eggs in 2 to 7 days (or with an average of 2.8 days) after emergence. The periods of fecundity (Table 5) varied from 6 to 10 days with an average of 8 days. The average number of eggs laid daily by a female (Table 5) ranged from 3 to 74 or an average of around 27 eggs, and the total number of eggs laid ranged from 194 to 234 eggs, with an average of 219 eggs (Table 5).

TABLE 5.—*Data on the reproduction of Pectinophora gossypiella in the laboratory from March 11 to June 28, 1935.*

	Duration
	Days
Period of fecundity (2 females):	
Maximum	10
Minimum	6
Average	8
Number of eggs laid daily by a female (2 individuals):	
Maximum	74
Minimum	3
Average	27.9
Total number of eggs laid by a female during period of fecundity (2 individuals):	
Maximum	234
Minimum	194
Average	219

The development of the insect from the time the eggs were laid to the time when the adults began to lay eggs, under laboratory temperatures ranging from 26.4 to 35.1° C, and relative humidities varying from 54.4 to 91.8 per cent ranged from 25 to 47 days, the mean being 30.9 days (Table 4). The corresponding mean laboratory temperature and relative humidity were 30.2° C and 70.6 per cent, respectively.

The longevity of adults was from 7 to 25 days, or an average of 14.8 days, under room temperatures ranging from 26.4 to 32.3° C, and relative humidities varying from 55.5 to 91.8 per cent (Table 4), the corresponding averages being 30.4° C and 73.8 per cent, respectively.

CONTROL-MEASURE SUGGESTIONS

The spotted bollworms.—In these studies on the life history and habits of the two spotted bollworms during the cotton seasons in 1935 and 1936, it was observed that infestations began during the latter part of December just before the beginning of the appearance of flower buds in January. From these observations, it would appear that cutting off the attacked shoots of cotton plants and picking and destroying all the early bolls showing signs of infestation will tend to minimize the infestation.

It is suggested that after harvest all cotton plants, including volunteer plants, be pulled out and burned, so that there is no food left for the insect in the cotton fields up to the next cotton season. As *Hibiscus esculentus* (okra) is an alternate host

of *E. fabia* as had been previously observed by Woodworth (1922) as well as on wild Malvaceous plants (Dammerman 1929), it would be advisable to destroy those that grow near or in cotton areas to prevent the insect from breeding before the cotton season. These two measures, otherwise known as clean-up measures, have proved a success in Egypt, where they have legislation demanding that all cotton plants, after harvest, be pulled out and burned together with the alternate hosts, *H. esculentus* and *H. cannabinus* (Gough 1919).

With regard to the use of insecticides, Deshpande and Nadkarny (1936) made extensive tests with lead arsenate, Paris green, calcium arsenate, and sodium silico-fluoride as means of control of *Earias fabia* and *E. insulana*. They applied the first two insecticides to the cotton plants in the form of dust or spray (at the rate of 2 ounces of lead arsenate to 4 gallons of water and $\frac{1}{2}$ ounce Paris green to 4 gallons of water), but found them ineffective in preventing damage by spotted bollworms. On the other hand, the same authors found out that calcium arsenate and sodium silico fluoride when used as dust have great possibilities of being useful in controlling the spotted bollworms provided that a very cheap and effective method can be devised in destroying the aphis infestation which develops after their use. Sodium silico-fluoride is more effective than calcium arsenate according to them. However, in the absence of the former, calcium arsenate may be employed for dusting, as in the United States against the Mexican boll weevil.

Pink bollworm.—Early matured bolls should be carefully examined, and those found attacked should be gathered and fumigated with carbon bisulphide or with a mixture of ethylene dichloride and carbon tetrachloride.

It is also suggested that after harvest, old plants and fallen bolls be destroyed by burning them. Volunteer plants during off season and alternate host, like the *Gossypium arborium* of the jayawant variety and other perennial varieties of cotton, especially those that are found near cotton fields, should be destroyed to prevent the insect from breeding there prior to the regular crop.

As most of the aestivating larvæ are found in the fastened seeds, it is suggested that all seeds for planting be fumigated or dried well before storing them in tightly closed containers.

TESTS WITH DERRIS ON EARIAS FABIA

On March 2, 1936, 5 caterpillars of *Earias fabia* were dusted in the laboratory with a fifty-fifty mixture (by weight) of derris dust and "gawgaw." The derris dust had a rotenone content of about 3 per cent. An hour after dusting, the caterpillars were observed paralyzed and all died within a day.

On March 24, 1936, the test was repeated on 10 caterpillars. It was observed too that the larvæ were paralyzed an hour after dusting, and on the second day all were dead.

In connection with these tests, it may be of interest to include the following observations made in relation to the dusting that was made with derris-gawgaw on cotton plants in one of the plots at the Philippine Carnival Exposition in 1936. The main purpose of dusting was to control the leaf-eating caterpillars, especially those of *Cosmophila erosa,* which were found abundant on the plants. The dusting was performed at about 9 o'clock in the morning. In the afternoon between 2 to 3 o'clock the plants were examined and collection was made of the insects found, especially those affected with the treatment. The insects collected were the following: 96 caterpillars of *Cosmophila erosa,* all paralyzed and 61 of them died after 2 days; 5 caterpillars of *Earias fabia,* all paralyzed and all died after 2 days; 19 adults of the local cotton boll weevil, *Amorphoidea lata,* all dead and were collected from inside the corolla of the flowers; 4 adults of cotton stainer, *Dysdercus megalopygus,* all dead; 9 lady bird beetles (predators), all dead; 4 hymenopterous insects, all dead and were collected from inside the corolla of the flowers; 16 larvæ of *Prodenia litura,* all vigorous and none died.

The results of the tests in the laboratory and in the open with derris-gawgaw indicate that the mixture has a promising value in the control, not only of the larvæ of *E. fabia,* but also of other insect enemies of cotton, and that further tests are necessary with the object of finding out, among other things, the rate and cost of application per hectare.

NATURAL ENEMIES

The pupa of *E. fabia* and that of the pink bollworm were found attacked by a hymenopterous parasite belonging to the Genus *Brachymeria.* The introduced egg parasite, *Trichogramma minutum,* was observed to parasitize readily the eggs of the

two spotted bollworms in test tubes. Tests conducted showed that 30 females of *T. minutum* could parasitize about 500 eggs of *Earias fabia.* The efficacy of using *T. minutum,* however, in the field remains yet to be studied.

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ILLUSTRATIONS

[The colored plate was prepared by one of the Bureau's former artists, Mr. Jose Olivares, and the photographs were taken by the Division of Publications, Department of Agriculture and Commerce.]

PLATE 1

FIG. 1. Adult of *Earias fabia.*
2. Adult of *Earias chromataria.*
3. Adult of *Pectinophora gossypiella.*
4. Larva of *E. fabia,* dorsal and side views.
5. Larva of *E. chromataria,* dorsal and side views.
6. Larva of *P. gossypiella,* dorsal and side views.
7. Cocoons of *E. fabia,* note the variation in color.
8. Eggs of *P. gossypiella.*
9. Pupa of *P. gossypiella.*
10. Egg of *E. fabia,* side and top views.

PLATE 2

FIG. 1. Portions of cotton shoots cut before the blooming stage, showing the injury by the larvae of *E. fabia.* A caterpillar is shown by an arrow.
2. Cotton plants with their shoots damaged by the larvae of *E. fabia.*

PLATE 3

FIG. 1. Cotton bolls and flower bud showing the larvae and the exit holes for the adults of *E. fabia.*
2. Cotton bolls attacked by the pink bollworm. Note how the lints are affected.

PLATE 4

FIG. 1. Fastened seeds of cotton containing aestivating larvae. These seeds passed through the cotton gin with the larvae in them uncrushed. Lower shows the same seeds opened.
2. Normally matured cotton bolls and abnormally matured ones due to the attack of the pink bollworm.

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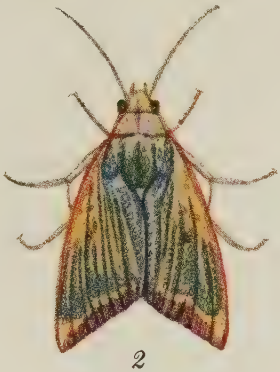

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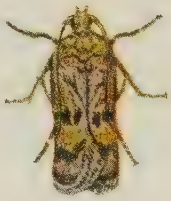

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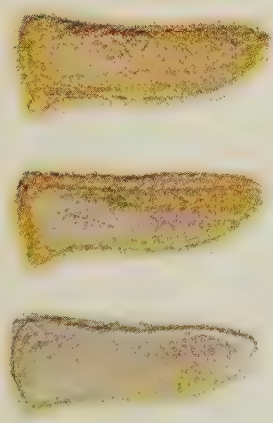

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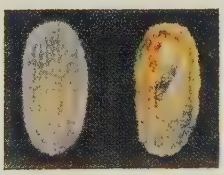

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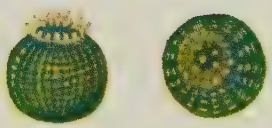

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PLATE 1

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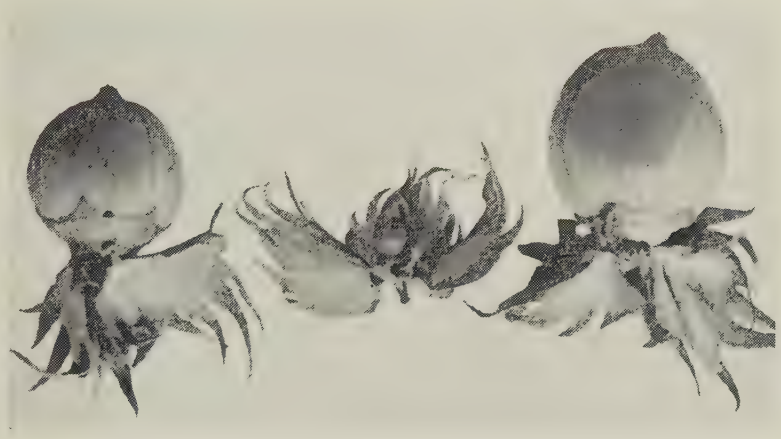
PLATE 2



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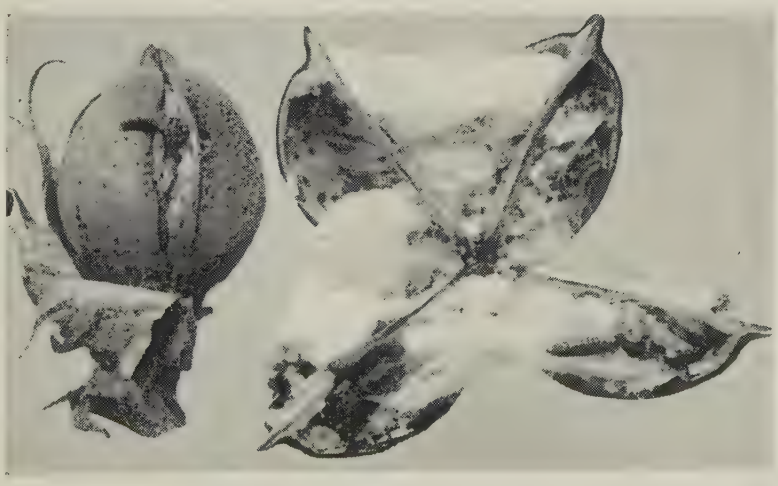

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PLATE 3

PLATE 4

VASCULAR DISEASE OF ABACÁ (MANILA HEMP) IN DAVAO

PROGRESS REPORT NO. 1

By MELANIO R. CALINISAN
Of the Plant Pathology Section, Bureau of Plant Industry, Manila

ELEVEN PLATES

A serious disease of abacá, or Manila hemp, (*Musa textilis* Née) with symptoms similar to banana wilt, or Panama disease, was observed in Davao. (Plates 1 to 8 and 11.) It first attracted public attention in the early part of 1937. Prior to November 11, 1936, Messrs. Bonifacio Padilla, Acting Provincial Agronomist of Davao, and Pastor R. Villanueva, Plant Sanitation Foreman, sent diseased abacá specimens to the Central Office, Bureau of Plant Industry, Manila, for identification and investigation. They reported that the abacá plants were entirely killed by the prevailing disease and that the extent of damage was very alarming. The specimens were collected from Mindanao Reclamation Company, Tongkalan, Guianga District. Studies have been conducted in the Plant Pathology Laboratory since then. From these specimens, a fungus and bacteria were isolated on November 21, 1936. At that time, however, the bacteria isolated were not given particular attention, because the specimen under study was already in a state of decomposition. Further ocular examination showed the presence of tunnel and a larva of a stem weevil.

On February 17, 1937, the writer made an investigation in Davao in compliance with the request made by Mayor Santiago Artiaga of the City of Davao, to the Director of Plant Industry on January 27, 1937. The first official report on this investigation was submitted to the Director on April 1, 1937.

In this investigation, it was revealed that the first occurrence of this particular abacá disease dated back as early as 1931–1932. It was first observed in the Upper Bayabas, Guianga District, 3,000 to 3,600 feet above sea level. At that time there was not much cause for alarm, because the foci of in-

fection were located only in localized sections of the plantations. In 1934, the disease was discovered in Mindanao Reclamation Company, Tongkalan, 1,600 to 1,750 feet in altitude. The same disease also appeared in Gumati in 1935. In December, 1936, it was noted in Serib and Manambulan. On June 16, 1937, the same disease was found in less than a hectare of abacá plantation in Lipadas, about 5 feet above sea level and 12 kilometers away from the nearest infected place. The writer's attempt to trace the possible introduction of the vascular disease from the higher altitude to the lower altitude failed. While it is true that the vascular disease of abacá was previously reported as prevalent only in higher altitude and has wrought considerable damage to the crop, it is equally true that at present the same trouble is also playing havoc on the plantations at lower elevations. The other places infected with the vascular disease of abacá are Daliaon Plantation, Barakayo Plantation, Eden Plantation, Catigan, Cabantian, and Malita. The total infected area surveyed up to July 31, 1937 was placed at 309.43 hectares, and the area freed from the disease was 54.11 hectares. The aggregate value of the damage was roughly estimated at between ₱200,000 and ₱300,000.

On February 3, 1937, the same disease was the subject of a report by Mayor Artiaga of Davao to the Director of Plant Industry. During the same month, Mr. H. T. Edwards, Fiber Expert of the U. S. Department of Agriculture and J. H. Permar of the United Fruit Co., brought the seriousness of this disease to the attention of the Honorable, the Secretary of Agriculture and Commerce, the Director of Plant Industry, and the officials of the Bureau of Plant Industry particularly concerned. The same disease was the subject of an appeal by the Davao Chamber of Commerce to the Director of Plant Industry. Before these reports and appeals were received, the investigations and eradication campaigns were already in progress. Since then, the situation became very much improved and all of the seriously infected plantations were gradually freed from the disease. More recently this work gained considerable momentum, because of the allotment of ₱6,000 with which to finance the eradication work.

On March 28, 1937, diseased abacá specimens from the higher altitudes of Gumati, Tongkalan, and Upper Bayabas were brought by the writer to the laboratory and were used in the studies now in progress. Species of *Fusarium* and bacteria

were again isolated on April 2, 1937. The bacteria were again discarded for the same reasons as previously mentioned. Diagnosis of the diseased plants showed symptoms resembling very closely those of banana wilt, or Panama disease (Plates 1 to 5). The vascular strands are similarly discolored (Plates 6, 7). On account of the infections of the vascular tissues, the disease is referred to as a vascular disease. On bananas, however, the color of the diseased vascular bundle is crimson purple, while on abacá, violet red. It was also noted that in many cases, tunnels produced by a weevil, *Odoiporus paganus* Uichanco, were found in the diseased plants (Plate 6). What relation this insect has to the disease is not as yet known.

On May 1, 1937, another field investigation was made. At the same time, eradication campaign on a large scale was organized. In this campaign the roguing method followed in the eradication of the bunchy-top disease of abacá was adopted (Plates 9, 10). This method consists of digging out all infected plants and destroying them completely by fire or by other means of eliminating sources of infection. Other diseases like bunchy-top and mosaic are also included in the eradication work.

In July, 1937, Ocfemia(6) reported that "the so-called 'new disease' of abacá in Davao is not a single trouble. It seems to be the combined effect of banana-wilt-like disease and the stem weevil on abacá forced to grow at high altitudes."

According to Lee and Serrano(1), Teodoro(2) and Teodoro and Serrano(3), the heart rot of abacá in the Philippines is caused by a fungus similar to, if not identical with, *Fusarium cubense* E. F. Smith. Ocfemia(4) reported that this fungus does not cause heart rot but it caused vascular infection. In a similar subsequent investigation, Leoncio(5) claimed that the fungus is capable of infecting abacá seedlings only through injuries of the corms and pseudostem. However, both Ocfemia and Leoncio concluded that the infected plants outgrow infection, and the plants recover from the disease. From the new abacá disease in question, however, no cases of recovery have been observed. Since the disease appears to be different from any of those previously reported on the abacá plant, the information here given may be of great value in further investigation of the disease, and for its ultimate control.

INVESTIGATION ON THE CAUSE OF THE DISEASE

Examination of 306 abacá plants showed that 109, or 35.62 per cent, manifested both the disease and the weevils or tunnels

produced by the weevils; 173, or 56.63 per cent, with vascular infection or the disease alone, no weevils or weevil's tunnel; and 24, or 7.84 per cent with weevils and tunnels but no sign of vascular infection.

From fresh and slightly infected abacá specimens collected at different plantations, isolation studies were again attempted. Bacteria of pure culture were oftentimes isolated from the corm, pseudostem, and even from the very tip of the discolored tissues of the petioles of the leaves. Records of this study also show that in many cases only pure culture of *Fusarium* was isolated from the corm or base of the plant, pseudostem, but not at the very tip of the discolored tissues of the particular diseased specimen. This finding made the writer suspicious. Cross sections of the discolored vascular tissues of the petioles and leaves were examined under the microscope and showed myriads of motile bacteria inside the xylem vessels, parenchymatous cells, and phloem.

In the present investigation which has been going on since November, 1936, the result shows that the disease is associated with bacteria and a fungus which is very similar to *Fusarium oxysporum* Schlt. f. 3 Wr. (*Fusarium cubense* E. F. Smith). A weevil, *Odoiporus paganus* Uichanco, is also found associated with the diseased plants. The predominance of the presence of bacteria on the diseased tissues over that of the fungus is very marked. The bacteria, the *Fusarium*, and the weevil are at present being used in the inoculation studies.

More extensive studies to complete this investigation are at present in progress in the Plant Pathology Laboratory, in Davao and in Silang Abacá Disease Experiment Station.

ACKNOWLEDGMENT

The writer wishes to take this opportunity to acknowledge the splendid coöperation of the Mayor of the City of Davao, of the Provincial officials of Davao Province, of the Davao Chamber of Commerce, of Mr. Kojima of the Ohta Development Co. and Mr. Kobayashi of the Davao Japanese Association and of the Director of the Oriental Hospital, for laboratory facilities, without which the solution of these important problems of the abacá industry would not be possible.

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ILLUSTRATIONS

Plate 1

Abacá plants (Maguindanao variety) attacked by the vascular disease. (Note the wilting of the leaves and breaking down at the base of the petioles.)

The specimen was collected from Mindanao Reclamation Co., Tongkalan, 1,750 ft. above sea level. Photographed February 25, 1937.

Plate 2

A close-up view of the specimen shown in Plate 1. Note (*a*) The rotting or blackening at the base of the pseudostem, (*b*) The flapping down of the dried infected leaf sheaths around the base of a diseased abacá plant. Compare this picture with Plate 3. The specimens were obtained from Mindanao Reclamation Co., Tongkalan, 1,750 feet above sea level. Photographed February 27, 1937.

Plate 3

Latundan variety of banana attacked by the banana wilt, or the so-called Panama disease. Note the blackening or rotting at the base of the plant and compare it with the symptoms produced on the abacá plants, Plate 2. This specimen was collected from Upper Bayabas Plantation, Guianga District, 3,000 feet above sea level. Photographed March 17, 1937.

Plate 4

A diseased pseudostem of an abacá plant, cut slantingly to show the discoloration of the fibrovascular bundles and around the pitch, or heart, of the plant. The natural specimen was collected from Mindanao Reclamation Co., Tongkalan, 1,750 feet above sea level. Compare this with Plate 5. Photographed February 27, 1937.

Plate 5

A portion of the pseudostem of a wilt-infected banana plant (Latundan variety), cut slantingly to show the discoloration of the fibrovascular bundles around the pith. Compare it with a diseased abacá plant on Plate 4. This specimen was collected from Upper Bayabas Plantation, 3,000 feet above sea level. Photographed March 17, 1937.

Plate 6

A longitudinal section of an abacá plant infected with the vascular disease. Note the discolored area on the corm. Note also the tunnel made by the larva of the weevil. The specimen was collected from Mindanao Reclamation Co., Tongkalan, Davao, 1,750 feet above sea level. Compare this with Plate 7. Photographed February 27, 1937.

PLATE 7

A longitudinal section of the corm of a banana plant infected with the wilt, or the Panama disease. Note the similarity in appearance of the discolored area on the corm with that of the abacá, as shown in Plate 6. The specimen was collected from Upper Bayabas, 3,000 feet above sea level. Photographed March 17, 1937.

PLATE 8

A portion of a 6-hectare abacá plantation (Maguindanao variety) seriously infected with the abacá vascular disease. Taken at Gumati Plantation, 2,650 feet above sea level. Photographed March 17, 1937.

PLATE 9

A portion of an abacá field badly infected with the vascular disease. Note the diseased plants that were cut at the middle of the stalks preparatory to digging. Taken at Mindanao Reclamation Co., Tongkalan, Davao, 1,600 feet above sea level. Photographed March 17, 1937.

PLATE 10

A portion of an abacá plantation previously infected with the vascular disease. Note that all the diseased plants have been dug out, at Mindanao Reclamation Co., Tongkalan, Davao, 1,750 feet above sea level. Photographed March 17, 1937.

PLATE 11

Diseased abacá suckers detached from infected mother plant of the Maguindanao variety. Note the ramifying growth of mycelium at the cut portion 24 hours thereafter. The specimen was taken from Serib, Guianga District, about 2,500 feet above sea level. Photographed March 2, 1937.

PLATE 1.

a *b*

PLATE 2

PLATE 3

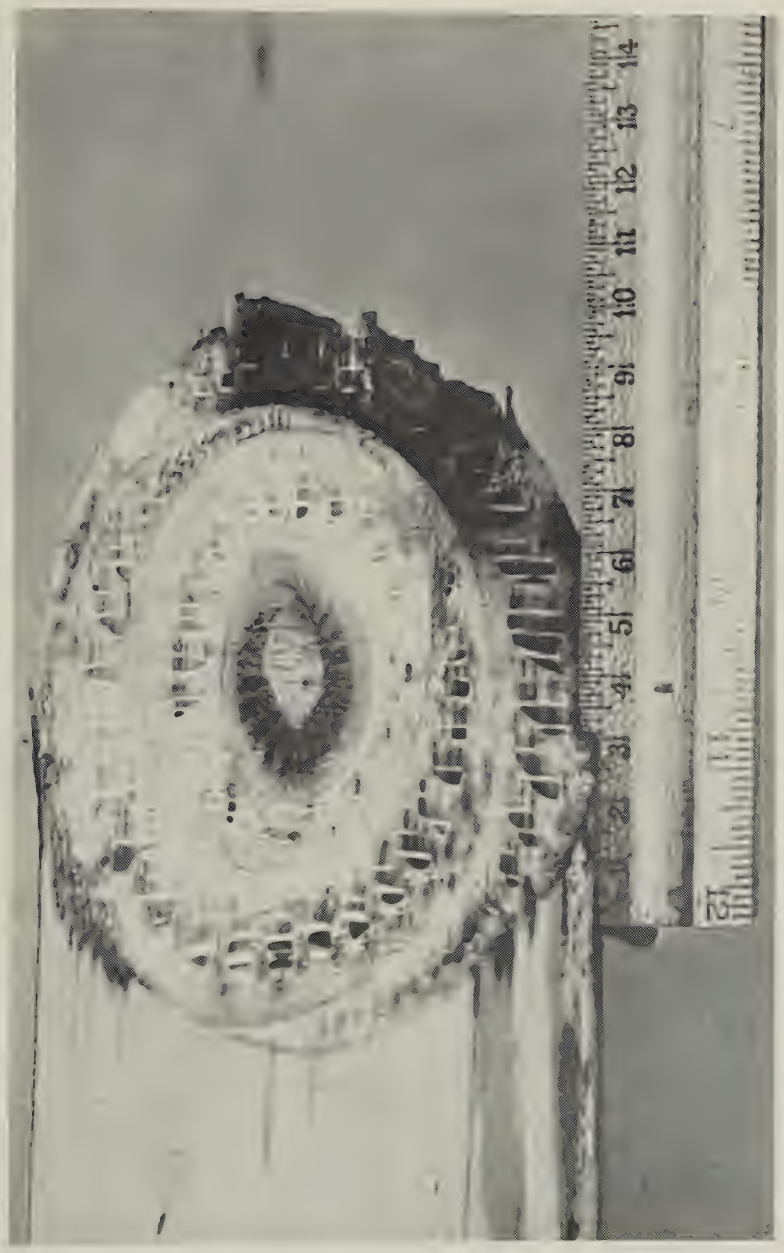

PLATE 4

PLATE 5

PLATE 6

PLATE 7

PLATE 8

PLATE 9

PLATE 10

PLATE 11

RESULTS OF CITRUS HYBRIDIZATION IN THE PHILIPPINES

By Juan P. Torres

Chief, Plant Breeding Section
Bureau of Plant Industry,
Manila

The first report(1) on citrus hybridization dealt primarily with the study of pollination and its technique, including the care of crossed flowers and fruits and the resulting plants while yet in the seed flat. The merits and demerits of some of the important parent varieties were also discussed. A brief discussion of the results of hybridization from 1928 to 1931 was also given.

In a more recent report(2), however, the nature of some of the materials used in hybridization as regards the number of embryo in the seed, was described. In addition, some of the important processes were briefly described with respect to their juvenile or transient characteristics, which were used to differentiate the hybrids from the non-hybrids or apogamous seedlings on the seed parents.

The present report gives further data and notes on citrus hybridization, including the results obtained during the last nine years. In order to devote the allowed space entirely for the discussion of the results of hybridization, the propagation and the planting of citrus hybrids in the testing orchards will be discussed in a separate article under the caption, "Propagation and Planting of Philippine Citrus Hybrids," to be published in a latter issue of this journal.

RESULTS

Prior to 1931 flowering season, only the successful crosses had been duly recorded and the failures were briefly accounted for. Seventy one crosses using 500 crossed flowers were then made, of which, only 6 crosses came out successful. The general failure was attributed to the more or less faulty or imperfect technique and to the fact that few flowers were used in most of the crosses, thus making no allowance for the natural falling of fruits due to physiological, pathological, or other troubles.

All the successful crosses produced in 1929 and 1930 are shown in Table 1, and the results of hybridization work from 1931 to 1936 flowering seasons, inclusive, are given in Tables 2, 3, 4, 5 and 6, respectively. The summary of the results is presented in Tables 7 (a) and 7 (b). The successful intraspecific and interspecific crosses are diagrammatically indicated in figure 1.

DISCUSSION OF RESULTS

The results of 1931 hybridization may be reviewed very briefly. There were 27 crosses with a total of 1,039 cross-pollinated flowers. Of the 11 intraspecific crosses, six were successful and of the 16 interspecific crosses, 3 came out successful. The large percentage of crosses which failed in that year was attributed to the rindborer *Prays citri,* which attacked the crossed

TABLE 1.—*Successful citrus crosses prior to 1931.*

Crosses	Date pollinated	No. flowers	No. fruits	No. seed	No seed-giving	No seed-ling	Number hybrids	
							Total	Selected
Szinkom mandarin x Bat. mandarin	2–12–29	26	9	[b]	[b]	16	3	2
Batangas x Szinkom	2–12–29	11	2	[b]	[b]	[a] 1	------	------
Szinkom x King mandarin	3–18–30	3	1	[b]	[b]	[a] 12	------	------
Orange N. 10 x Kishiu	1–29–29	2	1	[b]	[b]	[a] 5	------	------
Siamese 3442 x Saigon pomelo	5–19–30	11	10	[b]	62	62	62	17
Siamese 3442 x Vermilion pomelo	5–14–30	8	3	[b]	74	74	74	27

[a] Lost. [b] No record.

flowers and fruits at a young stage. Since all the crossed fruits had been allowed without any protective covering, the results obtained may serve as a measure of the relative susceptibility of the different seed parents to the rindborer. At that time, rindborers were specially abundant in the station, and were observed to have attacked severely the sweet oranges, pomelos, and limes. The mandarins and the lemons were the least attacked by these insects. Among the pomelos, Nueva Ecija P. I. No. 3910B had shown the greatest resistance. The failure of the crosses of Villafranca lemon with Thornless lemon and Siamese 3442 was due to the gumming disease which killed the branches before any of the crossed fruits reached maturity.

The foregoing results emphasize the fact that in hybridization, it is imperative to use certain protective covering, like cheese

cloth, so that the insects may be prevented from attacking the crossed flowers and young fruits and that healthy branches and twigs on which to perform hybridization should be carefully selected.

1932 Citrus hybridization.—In the 1932 flowering season there were 16 successful and 7 unsuccessful crosses embracing 719 crossed flowers (Table 3). In fact all the 23 crosses may be

TABLE 2.—*Results of 1931 citrus hybridization.*

Crosses	Date pollinated	No. flowers	No. fruits	No. seed	No. seed giving	No. seedling	Number hybrids	
							Total	Selected
INTRASPECIFIC CROSSES								
King mandarin x Batangas mandarin	5–22–31	39	11	(d)	179	174	179	15
Szinkom mandarin x Batangas mandarin	5–23–31	91	12	(d)	319	499	91	31
Szinkom x King	5–23–31	25	5	(d)	50	68	26	10
Szinkom x Tizon mandarin	5–25–31	38	12	(d)	130	167	48	28
Panuban grapefruit x McCarthy grapefruit	5–30–31	12	3	(d)	70	78	58	1
Siamese 3442 x Nueva Ecija pomelo	5–29–31	33	[a] 3					
Vermilion x Siamese 3442	5–29–31	8	[a] 5					
Wash. Navel x Laurel orange	5–22–31	146	[a] 5					
Wash. Navel x Orange N. 10	5–22–31	99	(b)					
Villafranca lemon x Thornless lemon	5–28–31	22	[e] 18					
INTERSPECIFIC CROSSES								
Bahia orange x Batangas mandarin	5–26–31	76	[a] 1					
Bahia x King mandarin	5–26–31	45	(b)					
Bahia x Tizon mandarin	5–20–31	19	(b)					
Wash. Navel x Tizon mandarin	5–25–31	20	(b)					
Bahia x Siamese 3442	5–26–31	81	(b)					
Bahia x Villafranca lemon	5–26–31	85	(b)					
Siamese 3673 pomelo x King mandarin	5–25–31	20	2	(d)	108	108	108	9
Siamese 3673 pomelo x Batangas	5–27–31	11	(b)					
Nueva Ecija x Bahia orange	5–27–31	12	(b)					
Siamese 3673 x Bahia orange	5–27–31	37	(b)					
Vermilion pomelo x Bahia orange	5–28–31	12	(b)					
Nueva Ecija pomelo x Thornless	5–29–31	14	(b)					
Siamese 3673 x Villafranca	5–27–31	12	(b)					
Villafranca lemon x Bahia orange	5–28–31	2	1	(d)	21	22	15	3
Villafranca lemon x Nueva Ecija pomelo	6–28–31	17	5	(d)	72	82	39	12
Villafranca x Siamese 3442	5–28–31	13	[e] 1					

[a] Dropped. [b] None set. [c] Branch diseased. [d] No record. [e] Second cross.

considered successful in so far as the production of crossed seeds is concerned. However, 2 of the 7 nobilis crosses, the Szinkom × China and the Szinkom × Kishiu, failed because the seeds were totally destroyed overnight in the germinating boxes by the black ants known in Tagalog as *quetib*. In this report the terms *mandarin crosses* and *nobilis crosses* are used interchangeably.

The crosses in which grapefruits were used, either as seed parent or pollen parent, produced rather weak hybrid seedlings that were highly susceptible to damping-off and to citrus canker *Pseudomonas citri*. In view of this fact only a few of the hy-

TABLE 3.—*Results of 1932 citrus hybridization.*

Crosses	Date pollinated	No. flowers	No. fruits	No. seed	No. seed-giving	No. seed-ling	Number hybrids	
							Total	Selected
CITRUS NOBILIS CROSSES								
Kishiu x Bat. 8865	6–3–32	63	1	12	12	12	12	2
Kishiu x China	6–5–32	30	2	36	33	33	33	2
Kishiu x Dancy	6–3–32	100	17	142	107	107	107	1
Kishiu x King	6–3–32	75	5	44	37	37	37	5
Kishiu x Szinkom	3–9–32	35	10	136	24	24	24	8
Szinkom x China	6–4–32	12	2	[a] 67				
Szinkom x Kishiu	6–4–32	16	2	[a] 78				
C. MAXIMA CROSSES								
Pink x La Union	6–8–32	14	1	77	82	82	82	2
Pink x Siamese 3142	6–4–32	12	4	192	181	181	181	3
Pink x Siamese 3673	6–8–32	16	1	111	103	103	103	3
Siamese 3442 x Pink	6–6–32	45	5	416	394	394	394	3
C. OVUCARPA CROSS								
Panuban x Marsh	6–4–32	40	1	18	2	[b] 2		
C. MAXIMA X C. OVUCARPA								
Pink x Marsh	6–7–32	24	2	150	136	136	136	2
Pink x Panuban	6–8–32	22	1	57	6	[b] 6		
Siamese 3142 x Panuban	6–7–32	5	1	100	93	93	93	4
Siamese 3142 x Duncan	6–8–32	21	1	125	108	108	108	3
Siamese 3442 x Marsh	6–5–32	13	2	49	45	45	45	2
OTHER INTERSPECIFIC CROSSES								
Kishiu mandarin x Jaffa orange	3–26–32	39	2	10	1	[b] 1		
Kishiu mandarin x Laurel orange	6–3–32	90	4	41	35	[b] 35		
Kishiu mandarin x Panubang grapefruit	3–12–32	10	2	12	4	[b] 4		
Szinkom mandarin x Laurel orange	6–4–32	19	11	215	5	[b] 5		
Villafranca C. x Kusaie lime	6–7–32	7	2	29	29	29	7	3
Siamese 3442 x Laurel orange	6–5–32	11	1	90	82	82	82	5

[a] Seed destroyed by ants.

[b] Died.

brids were selected for propagation and planting for further study.

All seedlings from the crosses of Panuban × Marsh, Pink × Panuban, Kishiu × Jaffa orange, Kishiu × Laurel orange, Kishiu × Panuban, and the Szinkom × Laurel orange died of damping-off disease several days after germination. As the seeds and hybrid seedlings are destroyed by ants, damping-off disease and citrus canker, it is desirable to take extremely good

TABLE 4.—*Results of 1933 citrus hybridization.*

Crosses	Date pollinated	No. flowers	No. fruits	No. seed	No. seed-giving	No. seed-ling	Number hybrids	
							Total	Selected
C. NOBILIS CROSSES								
China x Batangas 8865	5–15–33	53	25	212	160	327	69	31
China x King	5–17–33	71	34	196	122	233	57	16
China x Tizon	5–17–33	129	43	225	152	308	25	20
King x Calamandarin	5–19–33	27	15	175	149	156	149	32
King x Kishiu	5–15–33	41	25	259	223	227	223	60
King x Ladu	5–15–33	96	35	380	280	287	280	54
King x Szinkom	5–17–33	30	9	50	43	43	43	16
King x Tizon	5–13–33	36	20	75	61	61	61	17
Kishiu x Ladu	5–18–33	32	[d]					
Kishiu x Tizon	5–14–33	20	[d]					
Ladu x Batangas 8865	5–18–33	36	16	296	267	582	71	31
Ladu x King	5–17–33	28	5	76	66	155	25	21
Ladu x Kishiu	5–18–33	25	7	77	67	186	63	50
Ladu x Szinkom	5–17–33	23	5	46	36	150	11	10
Szinkom x China [a]	5–16–33	42	17	227	156	248	49	21
Szinkom x King [b]	5–18–33	13	6	76	53	78	11	1
Szinkom x Ladu	5–15–33	128	46	751	592	857	79	18
Tizon x King	5–19–33	35	2	[e]				
Tizon x Ladu	5–20–33	41	19	25	15	29	12	11
C. LIMONIA CROSS								
Villafranca x R. lemon	5–20–33	10	1	11	8	8	3	1
C. SINCURIS CROSS								
Wash. Navel x Laurel	5–20–33	83	6	36	32	64	20	[c] 3
INTERSPECIFIC CROSSES								
Calamonding x Ladu mandarin	5–17–33	53	36	270	143	270	60	20
Calamonding x Szinkom mandarin	5–17–33	47	29	72	40	92	18	None.
Kishiu x Calamonding	5–14–33	71	[f]					
Szinkom x Calamonding	5–12–33	74	14	238	162	292	27	20
Tahiti lime x Lemon	5–20–33	3	1	[e]				
Szinkom x Laurel [a]	5–13–32	36	9	124	96	146	15	11

[a] Second cross. [b] Third cross. [c] Still in the nursery.
[d] Branch diseased. [e] Seedless. [f] None set.

TABLE 5.—*Results of 1934 citrus hybridization.*

Crosses	Date pollinated	No. flowers	No. fruits	No seed	No. seed-giving	No seedling	Number hybrids	
							Total	Selected
CITRUS NOBILIS CROSSES								
King x Batangas B87	3-15-34	195	19	357	157	166	157	11
King x Dancy	3-16-34	118	38	800	563	576	563	36
King x Szinkom	3-16-34	130	20	233	120	128	120	7
King x Tizon [a]	3-16-34	36	8	100	62	64	62	9
Kishiu x Batangas B87	3-15-34	29	4	54	18	18	18	6
Kishiu x Batangas k4	3-14-34	74	4	61	27	27	27	10
Kishiu x Batangas k23	3-14-34	167	3	29	1	1	1	1
Kishiu x Batangas 8865 [a]	3-14-34	79	6	73	52	52	52	9
Kishiu x King [a]	4-26-34	15	(b)					
Kishiu x Tizon [a]	4-26-34	31	3	15	4	[d] 4		
Szinkom x Tizon	3-16-34	182	32	363	30	30	30	[f] 1
Szinkom x Batangas B87	3-13-34	146	(i)					
Szinkom x Batangas k4	3-13-34	75	4	109	50	72	15	13
Szinkom x Batangas k23	3-13-34	134	9	115	45	64	30	10
C. AURANTIFOLIA CROSS								
Kusaie x Native lime	3- 4-34	66	15	43	13	13	13	4
INTERSPECIFIC CROSSES								
Chinese pomelo x sour orange	3- 9-34	28	[e] 1					
Chinese x R. Lemon	3- 9-34	26	(g)					
Eureka lemon x Native lime	3- 8-34	11	(g)					
Kishiu x Calamonding [a]	4-26-34	35	1	6	6	[d] 6		
Kishiu x R. lemon	3- 4-34	61	(g)					
Lui Gim Gong orange x Kishiu	3- 4-34	40	1	8	8	[d] 8		
Lui Gim Gong x R lemon	3- 5-34	71	(g)					
Magnum Bonum x R. lemon	3-20-34	362	20	275	(h)	(h)	24	[f] 10
R. lemon x Sour orange	3- 8-34	192	139	2,110	819	1,607	38	6
Sour orange x R. lemon	3-19-34	155	15	647	319	385	56	(j)
Daidai x R. lemon	3- 5-34	68	(g)					
Szinkom mandarin x R. lemon	3- 4-34	61	29	571	(h)	(h)	20	[f] 8
Siamese 3442 x R. lemon	3- 9-34	30	(g)					
Siamese 3442 x Florida sour orange	3- 9-34	30	1	117	101	102	102	[f] 9
Villafranca lemon x Native lemon	3- 8-34	26	3	34	2	2	2	1
Kusaie lime x Eureka lemon	3- 4-34	10	3	15	3	3	3	3

[a] Second cross.
[b] Branch destroyed by wind.
[d] Died.
[e] Lost.
[f] Still in the nursery (8-31-3).
[g] None set.
[h] No record.
[i] Branch diseased.
[j] None.

care of the seeds and to disinfect or to sterilize the soils to be used for germinating these valuable crossed seeds. The failure to obtain healthy hybrid seedlings from 7 out of the 23 citrus crosses made in the 1932 flowering season was due to no other

cause than the lack of care of the seeds and young seedlings in the seed flats. In passing, it may be stated that in order to prevent damping-off, the soil in the seed flats should be sterilized thoroughly with hot or boiling water before sowing the seeds(1). The citrus canker may be easily prevented by spraying the seedling at close intervals with either Bordeaux mixture or lime sulphur solution(2).

1933 *Citrus hybridization.*—There had been attempted 27 different crosses during the flowering season of 1933, which comprised 1,283 cross-pollinated flowers (Table 4). Of the 19

TABLE 6.—*Results of 1935 and 1936 citrus hybridization.*

Crosses	Date pollinated	No. flowers	No. fruits	No. seed	No. seed-giving	No. seed-ling	No. Hybrids	
							Total	Selected
CITRUS NOBILIS CROSS								
Kishiu x Ladu [a]	6–20–36	64	3	24	22	22	22	(b)
INTERSPECIFIC CROSSES								
Siamese 3442 x Laurel mandarin oranges [a]	3–13–35	76	12	196	144	144	144	[d] 31
Siamese 3442 x Dougat mandarin oranges	3–14–35	64	8	170	126	126	126	[d] 32
S amese 3442 x Du. Roi. mandarin oranges	3–11–35	35	7	138	115	115	115	[d] 24
King mandarin oranges x Dougat mandarin oranges	3–10–35	37	4	75	50	52	50	9
King mandarin oranges x Laurel mandarin oranges	3–13–35	77	[e] 10	------	------	------	------	--------
King mandarin oranges x Dougat oranges [a]	6–20–36	65	27	120	119	131	119	(b)
Ladu mandarin oranges x Laurel mandarin oranges	6–20–36	158	34	382	344	644	------	--------

[a] Second cross.
[b] Seedlings still in seedbox.
[c] Hybrids not yet determined.
[d] Still in nursery.
[e] Fruits missing.

nobilis crosses, three were considered failure. The Kishiu × Ladu and Kishiu × Tizon crosses failed to produce fruits on account of the unexpected death of the branches bearing the crossed flowers, caused by a sudden attack by a severe pink disease. The Tizon × King cross gave two normal ripe fruits from 35 cross-pollinated flowers but without well-developed seeds. Tizon is a semiseedless variety, which may account for the failure of the seed to develop normal fruits. On the other hand, in the reversed cross, King × Tizon, there were produced 20 fruits out

of 36 crossed flowers, indicating that the Tizon × King is a case of cross incompatibility in only one direction. The Tizon × Ladu cross gave 19 matured fruits out of the 41 cross-pollinated flowers and only a total of 25 seeds. Seven of the fruits were without normal seeds showing partial sterility, producing a little better than one normal seed per fruit on the average.

The Kishiu × Calamonding cross produced no fruit from the 71 cross-pollinated flowers. These results tend to show cross-incompatibility at least in that direction. On the other hand, using Calamonding as seed parent, as in the crosses of Calamonding × Ladu and Calamonding × Szinkom, a good number of normal crossed fruits developed and a good number of hybrid seedlings were produced. The cross of Tahiti × Rough Lemon, consisting of three crossed flowers, produced one fruit without seed. Being a seedless variety of lime, the Tahiti may be expected to produce no normal seed. However, the experiment should be repeated, using a greater number of crossed flowers to verify these results.

1934 *Citrus hybridization.*—In the 1934 flowering season there were made 14 nobilis crosses, one aurantifolia cross and sixteen interspecific crosses (Table 5,), or a total of 31 different crosses embracing 2,683 cross-pollinated flowers. Of the 16 nobilis crosses, the Kishiu × King failed to set, because the branch broke off due to wind. The loss of the Szinkom × Batangas B87 was due to a sudden attack by severe pink disease on the branch bearing the crossed flowers. In the light of these losses, the selection of a branch which is healthy and strong enough to resist strong winds and the proper treatment of the branches in order to prevent any sudden attack by pink or other bark-rot diseases that might hamper the expected result, become important. As a preventive measure against any of these bark troubles, dressing the branches and trunks with lime sulphur paste will serve the purpose.

Of the sixteen interspecific crosses, no setting of fruits was found in the following six crosses: Chinese pomelo × R. lemon; Liu Gim Gong orange × Rough lemon; Siamese 3442 × Rough lemon; and Satsuma No. 2 or Daidai × Rough lemon. These failures may be considered cases of cross incompatibility, but they need further verification by using a greater number of crossed flowers. The young F1 hybrids from the crosses of

Kishiu × Calamonding (II) and Lui Gim Gong × Kishiu were very weak and highly susceptible to the attack of damping-off and citrus canker, to which their total failure to grow further was attributed. Young hybrids from the cross of Sour orange × Rough lemon were also found very weak.

1935 and 1936 Citrus hybridization.—There had been made one nobilis cross, Kishiu × Ladu, and seven interspecific crosses in the flowering seasons of 1935 and 1936, which covered 576 cross-pollinated flowers. Seven crosses in all came out successful, from which were obtained 1,105 seeds, 920 of which germinated, giving 1,234 seedlings. The fruits from the cross of King × Laurel orange were found missing.

GENERAL DISCUSSIONS

During the last nine flowering seasons, 187 different citrus crosses were made, 77 of which or about 41.2 per cent came out successful. Apparently, the greatest failure occurred during the first three flowering seasons. This great loss, as stated above, was due primarily to a more or less imperfect technique used and the lack of sufficient number of crossed flowers in many cases, not excluding the attack of rindborer on the crossed flowers and fruits. Due to the improvement attained in the technique, there had been a gradual increase in the percentage of success from 1931 to 1933 flowering season (see column 4 Table 7 [a]). However, there was a big drop in the percentage of successful crosses in 1934 due to the fact that in that season

TABLE 7(*a*).—*Results of citrus hybridization from 1928 to 1936 flowering seasons, inclusive.*

Year	Number of crosses			No. flowers	No. fruits	No. seed	No. seedgiving	No. seedlings	No. hybrids	
	Total	Successful							Total	Selected
		No.	Per cent							
1928–30	71	6	8.4	500	26	[a]	[b] 136	170	136	46
1931	27	9	33.3	1,039	58	[a]	1,365	1,634	980	141
1932	23	15	65.2	719	80	2,227	1,519	1,519	1,444	49
1933	27	22	81.4	1,283	429	3,917	2,923	4,799	1,371	464
1934	31	18	58.1	2,683	377	6,085	2,401	3,328	1,328	154
1935–36	8	7	87.5	576	105	1,105	920	1,234	576	118
Total	187	77	41.2	6,800	1,075	[b] 13,334	[b] 9,264	12,684	5,835	972

[a] No record.

[b] Incomplete.

16 of the 31 crosses attempted were interspecific crosses, nine of which failed. Some of the crosses did not set, while others produced very weak hybrid seedlings, so weak that they were all destroyed by the damping-off disease and citrus canker at the early stage.

In Table 7(b), it can be seen that from the 1931 to 1936 flowering seasons, there were made 45 mandarin crosses, 7 pomelos, 2 grapefruits, 3 oranges, 2 lemons, 1 lime, and 56 crosses between species.

Mandarin crosses.—Of the 45 mandarin crosses, 37 or 82.2 per cent were successful and 8 crosses or 17.8 per cent were failures. Total destruction of seeds by ants accounted for the loss in 1932 of the Szinkom × China and the Szinkom ×

TABLE 7(*b*).—*Kind of crosses attempted from 1928 to 1936 inclusive.*

Kind of crosses	Number of crosses			Remarks
	Total	Successful	Failure	
Mandarins	45	37	8	Failure due to nongenetic causes.
Pomelos	7	5	2	Do.
Grapefruits	2	1	1	Do.
Oranges	3	1	2	Do.
Lemons	2	1	1	Do.
Lime	1	1	0	
Interspecific	56	25	31	Six failures due to cross-incompatibility.
Miscellaneous 1928–30	71	6	65	Four failures due to cross-incompatibility.
Total	187	77	110	Ten failures due to cross-incompatibili.y.

Kishiu, while the sudden attack by a severe pink disease on the branches bearing the crossed flowers accounted for the loss in 1933 of the Kishiu × Ladu and the Kishiu × Tizon and of the Szinkom × Batangas B87 in 1934. The loss, in 1934, of Kishiu × King (II) was due to the destruction of the branch, and that of the Kishiu × Tizon was attributed to the weak hybrid seedlings which were killed by the damping-off disease. Based upon the results obtained from the hybridization of mandarins, it may be inferred that the different varieties are cross-compatible. The significance of this hybridization study points to the fact that in an orchard of mixed varieties of mandarins, cross-fertilization is highly probable to occur, since they are as a rule cross-compatible.

Pomelo crosses.—There were five successful crosses, and two crosses failed because of the rindborers which attacked the young fruits. Like the mandarins, the different varieties of pomelos may be regarded as cross-compatible with each other. The pomelos are monoembryonic, and all seedlings produced are from sexual embryos. Considering the fact that they are highly susceptible to cross-fertilization, it is, therefore, reasonable to expect many of the seedlings not to come out true to the type of the mother tree.

Other intraspecific crosses.—From the fact that both the Panuban grapefruit × McCarthy grapefruit and the Panuban × Marsh produced hybrid seedlings, it may be inferred that these varieties are cross-compatible. With oranges, the failure of Washington Navel × Laurel and Washington Navel × Orange No. 10 crosses in 1931 was attributed to the attack by the rindborers. It is believed that orange varieties may be crossed with each other easily, but the hybrids are indeed difficult to be sorted out from among the apogamous seedlings. The same was true with lemons and limes if crosses were made between varieties of the same species. Cross-compatibility between varieties of the same species is the rule in citrus and only one out of 60 varietal crosses presented here tends to show a doubtful case of cross-incompatibility. The Tizon × King may be considered a doubtful case of cross-incompatibility because the Tizon × Ladu cross had produced 19 fruits from 41 cross-pollinated flowers. Seven of the mature fruits were found seedless, while 12 fruits gave 25 normal seeds or a little over two seeds on the average: With more fruits than two produced from the cross of Tizon × King, similar result could have been obtained.

Interspecific crosses.—From the 56 species crosses, 25 crosses or 44.6 per cent were successful and 31 or 55.4 per cent were failures. Eleven species crosses failed most probably due to the attack of rindborers, inasmuch as no covering was employed after cross-pollination. In the later seasons, using cheese cloth as cover, the following crosses did not set fruits: Kishiu × Calamonding; Chinese pomelo × Rough lemon; Eureka lime × Native lime; Kishiu × Rough lemon; Lui Gim Gong orange × Rough lemon; Daidai × Rough lemon; and Siamese 3442 pomelo × Rough lemon. Those that died at the seedling stage on account of weak seedlings produced were: Pink pomelo × Panuban grapefruit; Kishiu mandarin × Jaffa orange; Kishiu × Laurel orange; Kishiu × Panuban; Szinkom mandarin × Laurel

orange; Kishiu × Calamonding (II); and Lui Gim Gong orange × Kishiu. The failure of four other species crosses was due to loss of fruits and death of the branches.

Cross-incompatibility in citrus.—Jones (5) defined incompatibility as the inability to accomplish fertilization in a particular mating. According to him, sterility resulting from incompatibility occurs when the parents crossed are alike with respect to particular sterility factor and also when they are germinally so dissimilar. Since citrus are generally self-fertile, the sterility factor theory as a cause of cross-incompatibility is out of consideration, thus giving favor to the theory of genetic differences. In avocado there are varieties that are cross-incompatible, others are compatible in only one direction while others had been successfully crossed either way (6), while in citrus, there is no clear-cut cross-incompatibility between varieties of the same species, but there are some varieties of different species that were found to be cross-incompatible. Other varieties, even though of different species, are cross-compatible. Refer to the diagram, Figure 1.

The results of interspecific hybridization show that the different species of citrus are to a certain extent cross-compatible, depending upon the varieties used in the cross. Mandarins were crossed successfully with Calamonding, oranges, grapefruits and lemon; Calamonding with mandarins; oranges with mandarins and lemon; sour orange with lemon; pomelos with mandarin oranges, sour oranges, and grapefruits; lemon with sour orange, pomelo with limes; and lime with lemons. However, it may be remembered that there are specific instances in which cross-incompatibility has been exhibited, as in the crossing of Siamese 3442, Chinese pomelo, Kishiu mandarin, Lui Gim Gong orange, Daidai, and Tahiti lime with Rough lemon. To these may be added the several attempts in 1930 to cross Siamese 3442 and Siamese 3673 with Kishiu mandarin and Calamonding and the King with Calamonding which also failed to bear fruits. Because of the fact that the hybrids produced were weak and died at a young stage, hence the crosses of Kishiu with Calamonding, Tizon, Jaffa, and Laurel oranges might be included in the group of cross-incompatible varieties, at least in the direction stated.

SUGGESTIONS REGARDING CITRUS HYBRIDIZATION

Based on the present and previous reports on the results and observations during the last nine flowering seasons, the

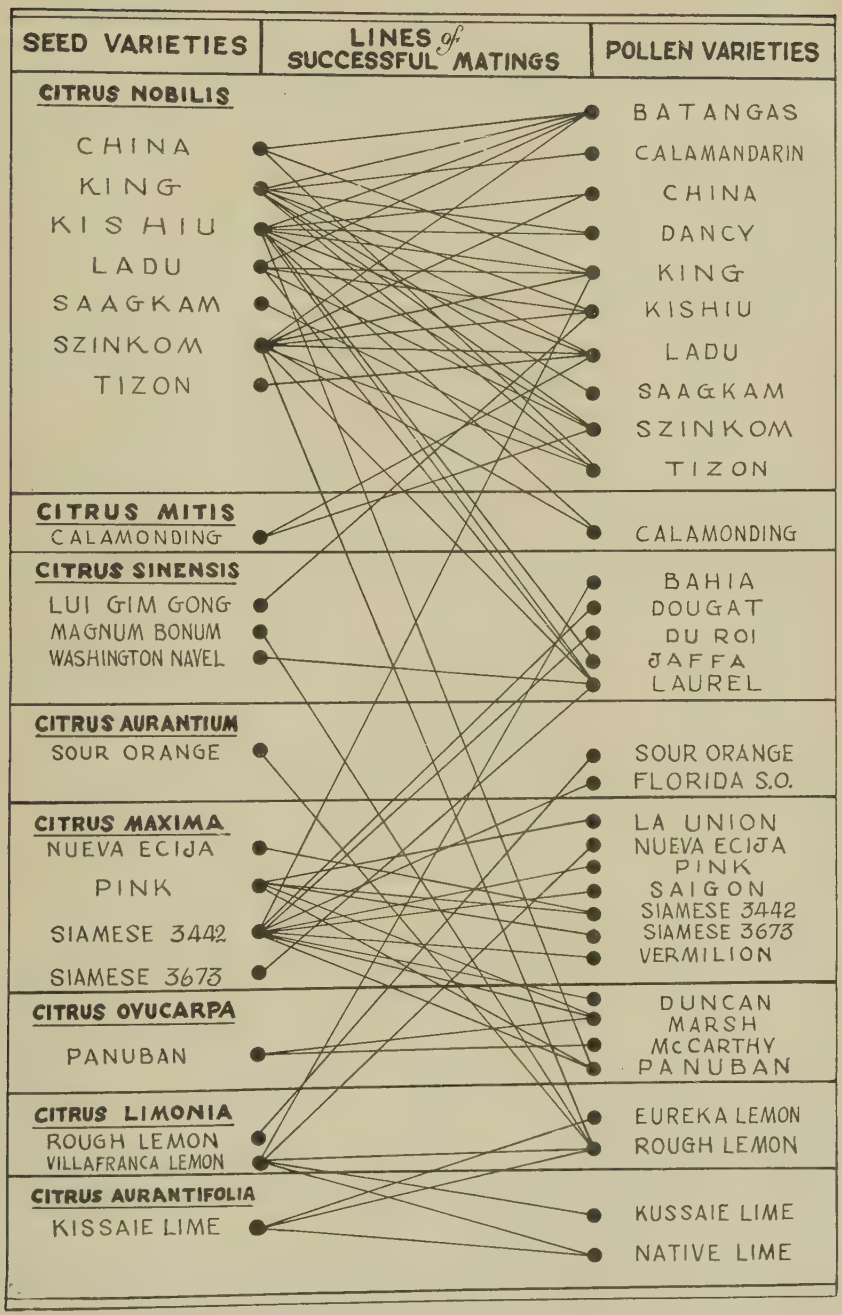

FIG 1.—Diagram showing successful intraspecific and interspecific citrus crosses.

following considerations may be important in connection with citrus hybridization.

1. Use the monoembryonic or the less polyembryonic types of citrus for seed parents and the polyembryonic ones as pollen parents. Polyembryonic varieties may be used as seed parents provided that the resulting F1 hybrid seedlings are easily recognizable from the apogamic seedlings of same.

2. Use for seed parents the varieties with tight articulation, i. e., less subject to windfall.

3. Select the healthy and strong branches and twigs on which to perform hybridization and apply from time to time a dressing of lime sulphur paste on the branches so as to prevent any sudden attack by pink or other bark diseases.

4. Study carefully the behavior of the parents with special reference to the time of opening of the flower, receptiveness of the stigma, and dehiscence of the pollen.

5. Emasculate the flowers in the afternoon preceding the day of opening and cover with cheesecloth bags the branches bearing the emasculated flowers. Emasculation may be done properly in the morning as the flowers begin to open or some hours before the pollen grains dehisced. There are varieties which open their flowers almost simultaneously with dehiscence. In those cases, emasculation should be done earlier.

6. Pollen is collected by picking flowers of the pollen parents that are about to open. When picked in the afternoon the pollen grains are ready for crossing on the following morning.

7. Use sufficient number of flowers, say 50 or more flowers for each cross, in order to insure setting of fruits.

8. Cover the cross-pollinated flowers with cheese cloth to protect them from contact with astray pollen and from the attack by rindborers and other insect pests.

9. Protect the crossed fruits from the attack by rindborers, green bugs, and other insect pests and citrus canker.

10. The crossed fruits may be harvested as soon as the fruits mature, not yet ripe.

11. After carefully extracting the seeds from the fruits, wash the seeds with clean water and spread and air-dry them for two hours or so before planting in seed flats.

12. Sterilize twice the soil in the seed flat with boiling water, taking care not to wash away the fertility of the soil. Sandy loam with well-rotted compost is the best soil compound for germinating the seeds.

13. Plant the seeds in the seed flats 2 to 3 centimeters apart and about one-half to one centimeter deep.

14. Give a thorough watering to the seed flats so as to insure a good start in germination and do not water while the seeds are germinating, unless the condition so warrants.

15. After germination keep the flats moist or well watered every day to obtain a normal rate of growth of the seedlings.

16. Prevent the outbreak of canker by applying from time to time either lime sulphur spray or Bordeaux mixture solution.

17. Observe the appearance of the seedlings as they grow in the seed flats and determine and study the differences between the hybrids and the apogamous seedlings or the check prepared for the purpose.

18. After four to six months, depending upon the size attained by the plants, select the hybrid seedlings for pricking either in pots, in seed flats or in beds. If pricking is done in seed flat, the distance should be 8 to 10 centimeters between the plants. In the seed flat, they may be allowed for several months until the weather and nursery conditions are favorable for transplanting them in the nursery beds where they are to be set about 40 to 50 centimeters apart.

SUMMARY

The results of citrus hybridization from 1929 to 1936 are here presented. Out of 187 crosses 77 were successful. Of the 45 mandarin crosses 37 were successful; of the 7 pomelos, 5; of 2 grapefruits, 1; of 3 oranges, 1; of 2 lemons, 1; one lime; and of the 56 interspecific crosses 25 were successful.

The results of intraspecific hybridization or mating of varieties from the same species indicate that cross-compatibility between varieties of the same species is the rule in citrus, whereas the results of interspecific hybridization show that the different species of citrus are cross-compatible to a certain extent, depending upon the varieties used in the cross.

Specific instances of cross-incompatibility between some varieties of different species are found in the matings of Siamese 3442, Chinese pomelo, Kishiu mandarin, Lui Gim Gong orange, Daidai, and Tahiti lime as seed parents with Rough lemon and in the direct and reciprocal crosses of Siamese 3442 and Siamese 3673 with Kishiu and Calamonding. The matings of Kishiu as seed parent with Calamonding, Tizon, Jaffa orange, and Laurel orange had produced very few seeds and very weak hybrid seed-

lings which died at a young stage, hence may be included in the group of semi-incompatible or doubtful cross-incompatible varieties, at least in the direction stated.

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THE EFFECT OF TRANSPLANTING PRICKED AND UNPRICKED TOBACCO SEEDLINGS OF DIFFERENT AGES UPON GROWTH AND YIELD.

By D. B. Paguirigan, F. de Peralta, and O. M. Casupang

Of the Tobacco Research Section, Bureau of Plant Industry

THREE TEXT FIGURES

Generally, healthy and well-developed seedlings, when transplanted in the field, turn out to be healthy and well-developed matured plants. But with regard to size and age of tobacco seedlings best for transplanting, in order to produce the highest yield possible, tobacco growers are at variance. Garner (1920) and Paguirigan (1925) advise that tobacco seedlings 12.5 to 15 cm high should be transplanted, and state that seedlings take about two months to attain this size. Brewer (1910) also states that under favorable conditions tobacco plants should be large enough to be transplanted in from six to eight weeks old from the time of sowing. Recently, Dalupang (1934) concluded that "on the whole—the 30-day-old and 37-day-old seedlings produced greater yields and better quality of leaves than 44-day-old and 51-day-old seedlings." The present paper reports the effects upon the growth and yield of tobacco in transplanting different ages of pricked and unpricked seedlings. The standard varieties of the three types of tobacco were tried, namely, (1) Ilagan Sumatra cigar wrapper type (open grown); (2) Simmaba, cigar-filler type; and (3) North-Carolina Bright Yellow and Samsoun Bafra, cigarette-filler type (Virginia and Turkish tobacco respectively). The experiment was conducted at Los Baños Economic Garden, Los Baños, Laguna, during the years 1935 and 1936.

MATERIALS AND METHOD

SEEDBED

Preparation of seedbed.—A level ground 46 meters long and 12 meters wide was selected for seedbed. The field was plowed and harrowed two times. Twenty-eight plots of 1.0 meter wide and 11 meters long were laid out as seedbeds. Paths 50 cm

wide separated the plots. The surface soil of the paths was removed and placed on the seedbeds. The earth on the seedbed was raised about a foot above the general level of the field. Previous to planting or sowing any of the seedbeds, the soil was forked and pulverized.

Sowing and pricking.—One square meter at the extreme left end of the seedbed was sown to tobacco seeds at the rate of 0.20 gram per square meter. At the same time, the adjacent 5-square-meter area of the seedbed was also sown to tobacco seeds at the rate of 0.10 gram per square meter. When the seedlings were 28 days old (from sowing) on the seedbeds, ten average-sized seedlings in the 5-square-meter area were selected, tagged, and measured. Hundreds of seedlings in the 1-square-meter area, approximately the same in growth development particularly as to number of leaves as the ones selected and measured, were carefully dug out and pricked at 10 centimeters apart on the remaining 5-square-meter area (right end of the seedbed) of the seedbed. The pricked and unpricked seedlings in the 5-square-meter sections of the seedbed were allowed to develop there until they were transplanted on the field on December 26, 1935. The other seedbeds were planted and treated similarly, but the sowing of the seeds was done at later dates at weekly intervals. The following table shows the dates of sowing, pricking, transplanting, and ages of seedlings during transplanting time:

Date of sowing	Date of pricking	Date of transplanting	Ages of seedlings
			Days
October 1, 1935	October 29, 1935	All the seedlings were transplanted on the same date—December 26, 1935.	86
October 8, 1935	November 5, 1935		79
October 15, 1935	November 12, 1935		72
October 22, 1935	November 19, 1935		65
October 29, 1935	November 26, 1935		58
November 5, 1935	December 3, 1935		51
November 12, 1935	December 10, 1935		44

[1] Age of seedlings was computed from date of sowing to transplanting.

THE FIELD

Preparation of field and transplanting of seedlings.—A level field 48 meters wide and 62 meters long previously planted to beans was used. It was plowed and harrowed three times at biweekly intervals previous to planting it to tobacco.

On December 26, 1935, the field was divided lengthwise into two equal parts. The first half was designated as lot A and the other half, lot B. In lot A, 30 lengthwise furrows at 80 cm apart were laid out, after which the lot was divided crosswise into two sections, C and D. The first 15 furrows in section C were planted to Ilagan Sumatra seedlings. Fifty-two uniformly developed plants, spaced at 50 cm apart, were planted in each furrow. The plants planted in the first furrow were considered as border plants. The seedlings planted in the second and third rows were 86 days old, but pricked seedlings were planted in the second row, and the unpricked ones, in the third row. The fourth and fifth rows, the sixth and seventh rows, the eighth and ninth rows, the tenth and eleventh rows, the twelfth and thirteenth rows, and the fourteenth and fifteenth rows were also planted to tobacco, 79, 72, 65, 58, 51, and 44-day-old pricked and unpricked seedlings respectively, that is, the pricked and unpricked seedlings of the same age, alternating each other. The other 15 furrows in section C were planted to Samsoun Bafra. The number, distance between plants, treatment, and age of the seedlings transplanted were the same as those of the Ilagan Sumatra.

In Section D, fifteen furrows were planted to Simmaba. Fifty-two seedlings were also planted to a furrow, and spaced at 70 cm apart. Pricked and unpricked seedlings were planted. The ages of the seedlings employed were the same as those of Ilagan Sumatra planted in section C. With the same condition and in the same manner as in Simmaba, the remaining 15 furrows were planted to North Carolina Bright Yellow.

Lot B was a duplicate culture of lot A. The conditions and treatments given to lot A were followed in lot B.

Care of plants.—The transplanted seedlings were not shaded but were watered quite freely. Watering was done every other afternoon during a period of one week.

The spaces between the rows were plowed a week after transplanting, while the spaces between the hills were dug with hoes. The field was kept clean during the whole growth development.

OBSERVATION

On the seedbed.—Ten plants, each of pricked and unpricked seedlings from the 4 varieties used, were measured for growth development. The length of the leaf was measured from the

axil to the tip, and the measurement of the width was taken at its widest part. The length was multiplied by the width of each leaf, and the product is called "leaf product," which is used in this study as a measure of the vegetative growth development of the plant. The leaf products of all the leaves of the ten plants measured were added together, and the sum was divided by 10. The quotient represents approximately the average total leaf area of one plant.

Previous to transplanting the seedlings in the field on December 26, 1935, the following records were gathered: (*a*) Average total leaf product of green leaves, (*b*) average measurement of length and width of biggest leaf of a plant, (*c*) average height of seedlings, and (*d*) average circumference of stem.

On the field.—There was no rain during the first week after transplanting. After the end of the first week, the number of dead plants in a row was counted and the percentage of death based on 50 plants was calculated. Vacant spaces were replanted.

Thirty-two days after transplanting, 10 average-sized plants from each row of Ilagan Sumatra and Simmaba varieties were observed for (*a*) number of leaves produced, (*b*) measurement of length and width of largest leaf developed on a plant, and (*c*) total leaf product of green leaves of one plant. The other two varieties, Samsoun Bafra and North Carolina Bright Yellow, were not observed at this time.

One day previous to the first priming, all the green leaves of 10 average-sized plants from all the rows, both in lots A and B, were measured. Priming was started when the flower buds of the plants were appearing. Harvesting was continued thereafter at weekly intervals until all the leaves were gathered. Fresh and dry weight of all leaves harvested from twenty-five average-sized plants from each row were recorded.

RESULTS

The results of this experiment are presented in tabulated forms and grouped into three, namely, (*a*) growth rate development of pricked and unpricked seedlings on the seedbed (Tables 1, 2, 3, and 4); (*b*) the after effect of transplanting different sizes of pricked and unpricked seedlings on the field (Tables 5, 6, 7, 8 and 9); and (*c*) the effect of age upon growth and yield (Tables 10 and 11).

TABLE 1.—*Development of different ages*[a] *of pricked and unpricked Ilagan Sumatra seedlings on the seedbed at different times of the year.*

Date of sowing	Average total leaf products of seedlings						
	28 days old	49 days old		63 days old		77 days old	
		Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1935	*Sq. cm.*	*Sq. cm.*	*Sq cm.*	*Sq. cm.*	*Sq. cm.*	*Sq. cm.*	*Sq. cm.*
October 1	9.9	69.8	105.8	335.9	461.2	1,358.8	1,056.7
October 8	10.5	79.2	115.0	303.6	572.8	1,272.2	969.7
October 15	11.8	65.5	140.7	329.0	597.8		
October 22	10.0	74.2	124.5	320.2	566.0		
October 29	9.0	70.5	104.7				
November 5	9.5	64.0	111.2				
November 12	9.4						
Average	10.10	70.5	117.0	322.2	549.5	1,315.5	1,012.2

[a] Seedlings were pricked when they were 28 days old from the date of sowing.

TABLE 2.—*Development of different ages*[b] *of pricked and unpricked Simmaba seedlings on the seedbed at different times of the year.*

Date of sowing	Average total leaf products of seedlings						
	28 days old	49 days old		63 days old		77 days old	
		Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1935	*Sq. cm.*	*Sq. cm.*	*Sq cm.*	*Sq. cm.*	*Sq. cm.*	*Sq. cm.*	*Sq. cm.*
October 1	7.8	31.1	78.9	226.4	390.3	1,049.8	702.5
October 8	6.5	59.4	62.5	298.5	417.9	1,397.5	806.7
October 15	9.9	51.7	80.5	376.5	541.5		
October 22	11.5	80.5	120.8	385.5	898.0		
October 29	8.5	49.6	85.0				
November 5	10.5	57.3	95.3				
November 12	7.0						
Average	8.80	54.93	87.17	321.73	561.93	1,223.65	754.6

[b] Seedlings were pricked when they were 28 days old from the date of sowing.

TABLE 3.—*Development at different ages*[a] *of pricked and unpricked North Carolina Bright Yellow (NCBY) seedlings on the seedbed at different times of the year.*

Date of sowing	Average total leaf products of seedlings						
	28 days old	49 days old		63 days old		77 days old	
		Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1935	*Sq. cm.*	*Sq. cm*	*Sq. cm.*	*Sq. cm.*	*Sq. cm.*	*Sq. cm.*	*Sq. cm.*
October 1	18.2	109.0	184.0	448.0	811.9	1,652.2	1,350.1
October 8	15.6	104.5	167.5	401.2	873.0	1,770.7	1,370.0
October 15	19.4	117.0	192.2	492.0	836.0		
October 22	22.1	156.9	282.3	1,127.7	1,309.5		
October 29	20.2	165.3	204.0				
November 5	19.2	106.4	196.0				
November 12	17.3						
Average	18.86	126.5	204.33	617.2	957.6	1,711.45	1,360.05

[a] Seedlings were pricked 28 days after sowing.

TABLE 4.—*Development of different ages*[b] *of pricked and unpricked Samsoun Bafra seedlings on the seedbed at different times of the year.*

Date of sowing	Average total leaf products of seedlings						
	28 days old	49 days old		63 days old		71 days old	
		Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1935	*Sq. cm.*	*Sq cm.*	*Sq. cm.*	*Sq cm.*	*Sq cm.*	*Sq. cm.*	*Sq cm.*
October 1	12.2	82.6	105.7	754.2	793.4	1,787.0	1,588.0
October 8	11.5	85.0	101.0	789.4	872.4	1,851.1	1,701.5
October 15	13.0	95.7	109.0	845.5	931.0		
October 22	14.2	125.0	295.5	1,007.0	1,131.9		
October 29	13.2	90.7	158.0				
November 5	12.2	77.6	108.9				
November 12	11.9						
Average	14.0	97.77	146.35	849.025	932.175	1,819.05	1,544.75

[b] Seedlings were pricked when they were 28 days old from the date of sowing.

TABLE 5.—*Development of different ages of tobacco seedlings at the time of transplanting and percentage of death a week after transplanting.*

Ilagan Sumatra	Size of seedlings at transplanting time at different ages					
	44		51		58	
	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1. Average total leaf products of green leaves—sq. cm.	40.2	85.5	86.5	127.0	202.5	388.1
2. Average measurement of length and width of biggest leaf—cm. L	4.2	6.0	7.0	10.0	12.1	13.5
2. Average measurement of length and width of biggest leaf—cm. W	2.2	3.5	3.5	5.5	7.8	7.8
3. Average height of seedlings—cm.	[a]	3.0	0.5	5.0	5.0	10.0
4. Average circumference of stem—cm.	[a]	0.9	[a]	1.0	1.0	1.2
5. Per cent death-effect of transplanting	24	10	18	4	8	0

Ilagan Sumatra	Size of seedlings at transplanting time at different ages							
	65		72		79		86	
	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1. Average total leaf products of green leaves—sq. cm.	332.5	560.5	822.5	807.1	1,315.1	1,103	1,637.0	1,286.3
2. Average measurement of length and width of biggest leaf—cm. L	13.5	14.0	18.0	18.5	24.0	20.0	25.0	21.5
2. Average measurement of length and width of biggest leaf—cm. W	7.5	8.0	9.0	9.0	14.0	9.5	16.0	12.5
3. Average height of seedlings—cm.	12.0	12.0	14.0	14.5	30.0	26.0	40.0	32.0
4. Average circumference of stem—cm.	2.2	1.3	3.0	1.3	3.4	1.8	4.2	2.0
5. Per cent death-effect of transplanting	0	0	0	6	20	14	24	26

[a] In rosette form.

TABLE 6.—*Development of different ages of tobacco seedlings at the time of transplanting and percentage of death a week after transplanting.*

Simmaba	Age of seedlings in days at transplanting time					
	44		51		58	
	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1. Average total leaf products of green leaves—sq. cm.	44.0	65.6	59.4	91.2	192.2	325.7
2. Average measurement of length and width of biggest leaf—cm.	L 4.8	5.5	6.5	7.5	9.5	10.5
	W 2.5	3.5	3.5	4.5	5.0	6.0
3. Average height of stem—cm.	[a]	3.5	[a]	5.0	3.0	12.0
4. Average circumference of stem—cm.	[a]	1.2	[a]	1.5	1.6	1.8
5. Per cent death-effect of transplanting	22	14	20	6	12	2

Simmaba	Age of seedlings in days at transplanting time							
	65		72		79		86	
	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1. Average total leaf products of green leaves—sq. cm.	332.5	563.0	787.5	661.0	1,235.0	759.0	1,655.5	853.5
2. Average measurement of length and width of biggest leaf—cm.	L 12.5	15.0	23.0	22.0	26.0	25.0	28.0	27.0
	W 6.0	7.2	11.0	10.0	10.0	11.0	13.0	11.5
3. Average height of stem—cm.	10.0	14.0	17.5	17.0	25.0	18.0	30.0	20.0
4. Average circumference of stem—cm.	2.4	2.0	2.6	2.1	3.0	2.2	3.3	2.3
5. Per cent death-effect of transplanting	0	2	8	10	14	10	18	22

[a] In rosette form.

TABLE 7.—*Development of different ages of tobacco seedlings at the time of transplanting and percentage of death a week after transplanting.*

North Carolina Bright Yellow	Age of seedlings in days at transplanting time					
	44		51		58	
	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1. Average total leaf products of green leaves ---sq. cm	98.1	154.8	134.5	216.4	379.5	590.9
2. Average measurement of length and width of biggest leaf ---cm	L 6.0	9.0	9.0	12.8	14.2	15.9
	W 4.0	5.2	4.5	5.0	6.0	7.6
3. Average height of seedlings ---cm	[a]	4.0	[a]	5.5	3.0	12.5
4. Average circumference of stem ---cm	[a]	1.3	[a]	1.6	1.9	2.3
5. Per cent death-effect of transplanting	12	6	10	2	4	2

North Carolina Bright Yellow	Age of seedlings in days at transplanting time							
	65		72		79		86	
	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1. Average total leaf products of green leaves ---sq. cm	631.5	967.5	1,177.5	1,168.5	1,723.4	1,369.3	2,081.2	1,829.3
2. Average measurement of length and width of biggest leaf ---cm	L 17.0	18.0	24.0	22.5	27.0	25.5	29.0	27.5
	W 9.0	9.0	12.0	11.0	12.5	11.5	13.0	12.0
3. Average height of seedings ---cm	9.5	13.5	18.5	17.5	20.5	19.0	24.5	21.0
4. Average circumference of stem ---cm	2.1	2.5	3.3	2.3	3.5	2.5	3.5	2.5
5. Per cent death-effect of transplanting	0	2	8	4	10	12	10	14

[a] In rosette form.

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TABLE 8.—*Development of different ages of tobacco seedlings at the time of transplanting and percentage of death a week after transplanting.*

Samsoun Bafra	Age of seedlings in days at transplanting time					
	44		51		58	
	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1. Average total leaf products of green leaves.....sq. cm..	77.1	113.4	105.8	157.5	477.0	549.5
2. Average measurement of length and width of biggest leaf.....cm..	L 4.0	8.0	7.5	11.0	13.0	15.0
	W 3.7	5.0	5.0	6.5	9.5	8.5
3. Average height of seedlings.....cm..	[a]	2.5	[a]	6.0	4.0	14.0
4. Average circumference of stem.....cm..	[a]	1.0	[a]	1.3	1.9	1.8
5. Per cent death-effect of transplanting.....	12	6	10	2	4	2

Samsoun Bafra	Age of seedlings in days at transplanting time							
	65		72		79		86	
	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
1. Average total leaf products of green leaves.....sq. cm..	855.0	942.9	1,427.3	1,298.5	1,903.3	1,648.5	2,358.3	1,962.5
2. Average measurement of length and width of biggest leaf.....cm..	L 17.0	18.0	18.0	19.0	20.0	19.5	21.0	20.5
	W 11.0	11.0	11.0	11.0	12.0	11.0	12.5	11.0
3. Average height of seedlings.....cm..	12	17	17.0	20	29	27	39	36
4. Average circumference of stem.....cm..	2.0	2.0	2.5	2.4	2.5	2.3	2.7	2.6
5. Per cent death-effect of transplanting.....	0	2	2	4	10	12	10	14

[a] In rosette form.

TABLE 9.—*Growth rate of tobacco plants 32 days after transplanting on the field.*

Variety and criteria considered	Age of seedlings in days at transplanting time					
	44		51		58	
	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
ILAGAN SUMATRA						
1. Average number of leaves [a]	6.5	6.5	7.0	7.5	8.0	9.5
2. Average measurement of length and width of largest leaf—cm.	L 19.5	20.5	20.0	23.5	24.0	27.5
	W 11.7	12.7	12.5	15.0	15.5	17.2
3. Average leaf product of green leaves—sq. cm.	171.2	524.5	801.8	1,359.9	2,067.9	3,210.2
4. Growth rate increase (leaf product)—per cent	325	513	827	971	921	727
SIMMABA						
1. Average number of leaves [a]	7.5	7.5	8.0	8.5	9.0	10.0
2. Average measurement of length and width of largest leaf—cm.	L 26.5	30.0	30.5	31.0	34.5	38.5
	W 12.0	15.0	14.0	17.0	18.5	22.5
3. Average leaf product of green leaves—sq. cm.	170.2	352.1	534.4	904.8	1,920.2	3,262.2
4. Growth rate increase (leaf product)—per cent	287	436	799	892	899	901

TABLE 9.—*Rate of tobacco plants, etc.*—Continued.

Variety and criteria considered	Age of seedlings in days at transplanting time							
	65		72		79		86	
	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked	Pricked	Unpricked
ILAGAN SUMATRA								
1. Average number of leaves [a]	8.0	10.0	10.5	9.5	13.0	10.5	14.5	11.0
2. Average measurement of length and width of largest leaf, cm	27.5	31.5	30.7	28.5	31.2	29.5	27.2	28.0
	18.0	21.2	18.5	17.5	20.7	19.7	15.7	17.2
3. Average leaf product of green leaves, sq. cm.	2,595.4	3,525.2	3 345.2	2,989.8	3,914.3	2,755.8	3,505.0	1,633.5
4. Growth rate increase (leaf product), per cent	681	529	307	270	198	149	114	27
SIMMABA								
1. Average number of leaves [a]	11.5	11.0	11.5	10.0	10.5	9.5	10.0	9.5
2. Average measurement of length and width of largest leaf, cm	43.5	45.5	43.0	37.0	39.5	37.0	37.0	28.5
	23.5	22.5	24.0	16.0	20.5	17.5	18.5	12.0
3. Average leaf product of green leaves, sq. cm.	3,125.6	5,147.9	4,931.8	4,020.4	5,590.4	2,810.0	4,991.2	2,031.1
4. Growth rate increase (leaf product), per cent	840	814	526	508	352	270	201	138

[a] Number of leaves includes dry, yellow, and green leaves.

TABLE 10.—*Average total leaf product (green leaves) of one plant at priming period.*

Age of seedlings at transplanting	Ilagan Sumatra		Simmaba	
	Pricked	Unpricked	Pricked	Unpricked
Days	*Sq. cm.*	*Sq. cm.*	*Sq. cm.*	*Sq. cm.*
44	9,293.7	11,342.8	9,089.8	12,499.3
51	13,217.5	14,213.2	16,639.5	16,985.9
58	14,200.4	14,011.2	17,832.5	17,794.5
65	12,950.1	11,024.2	17,432.4	16,998.5
72	11,375.1	10,207.8	15,309.7	14,942.4
79	10,952.4	9,093.7	12,925.6	10,942.0
86	8,954.2	6,729.3	10,717.9	8,438.4

TABLE 11.—*Computed yield per hectare based upon harvest data of 25 tobacco plants.*

Variety and distance of planting	Age of seedling	Pricked				Unpricked			
		Fresh weight	Dry weight	Water content[a]	Yield per hectare	Fresh weight	Dry weight	Water content[a]	Yield per hectare
	Days	*Grams*	*Grams*	*Per cent*	*Quintal*	*Grams*	*Grams*	*Per cent*	*Quintal*
ILAGAN SUMATRA (Wrapper type)	44	6,501	910	86	18.2	7,854	1,021	87	20.4
	51	7,354	1,016	87	20.3	9,286	1,301	86	26.0
	58	8,500	1,275	85	25.5	9,143	1,280	86	25.6
80×50 cm.	65	8,257	1,156	86	23.1	8,462	1,100	87	22.0
	72	7,578	1,071	86	21.4	6,614	926	86	18.5
	79	6,106	916	85	18.3	5,471	766	86	15.3
	86	5,808	755	87	15.1	4,769	620	87	12.4
SIMMABA (Cigar-filler type)	44	9,433	1,415	85	20.2	12,664	1,773	86	25.2
	51	12,659	1,772	86	25.3	14,250	2,137	85	30.5
	58	17,669	2,297	87	32.8	16,300	2,282	86	32.0
80×70 cm.	65	16,916	2,199	87	31.4	14,366	2,155	85	30.7
	72	14,360	2,154	85	30.7	14,164	1,983	86	28.3
	79	12,657	1,772	86	25.3	11,107	1,555	86	22.2
	86	8,850	1,416	84	20.2	7,140	1,071	85	15.3
NORTH CAROLINA BRIGHT YELLOW (Virginia cigarette-filler type)	44	7,914	1,197	85	17.1	9,331	1,401	84	20.0
	51	10,915	1,429	87	20.4	14,007	1,821	87	26.0
	58	12,657	1,772	86	25.3	12,557	1,758	86	25.1
80×70 cm.	65	11,020	1,653	85	23.6	10,833	1,625	85	23.2
	72	10,877	1,414	87	20.2	10,078	1,417	86	20.2
	79	8,540	1,281	85	18.3	7,053	1,058	85	15.1
	86	7,550	1,057	86	15.1	6,002	840	86	12.0

SAMSOUN BAFRA (Turkish cigarette-filler type) 80×50 cm.	44	4,400	660	85	13.2	5,401	756	86	15.1
	51	6,654	865	87	17.3	7,307	950	87	19.0
	58	6,457	904	86	18.1	6,160	924	85	18.5
	65	5,700	761	87	15.2	4,329	606	86	12.1
	72	4,386	614	86	12.3	3,726	559	85	10.2
	79	3,566	535	85	10.7	3,277	426	87	8.5
	86	3,250	455	86	9.1	2,600	364	86	7.3

[a] Water content based on fresh weight of leaves.

[b] 1 Quintal = 50 kg. (gross weight) instead of 46 kg. (net weight).

DISCUSSION OF RESULTS

Growth rate of pricked and unpricked seedlings on the seedbed compared.—When the root system of a tobacco seedling was disturbed during its early period of growth or seedling stage, the growth rate of the leaves during that period was greatly retarded (Tables 1, 2, 3, and 4). The total leaf products of the seedlings developed from seeds of Ilagan Sumatra sown on October 1 and 8, 1935 (Table 1) and pricked at the age of 28 days, compared to unpricked seedlings of the same age, three weeks later, were 34.6 and 31.1 per cent smaller, respectively. And, when compared again two weeks after, still the pricked plants were smaller. This behavior of growth development is not only exhibited by the October planting but also by the November planting. This is also true in the other three varieties of tobacco studied (Tables 2, 3, and 4). But after the pricked seedling had reëstablished its root system, the growth rate of the seedling was greatly accelerated. Seven weeks after pricking, the total leaf products of pricked seedlings were bigger than the leaf products of unpricked plants (Tables 1, 2, 3, and 4). The retardation of the rate of growth of the pricked seedlings following pricking operation (around 5 weeks) is due to the fact that pricking is a violent operation, because the young roots with their root hairs are torn away. In a previous paper (Peralta and Paguirigan 1936) the following observation was made:

> In spite of the extreme precaution resorted to during the time of pricking, the tip of the primary root was broken in the course of lifting.

The root tips and root hairs are the most important parts of the root system for absorption. Unless more roots are produced with a short period of time, after pricking, the normal rate of absorption of pricked seedlings is impaired. Under this state of condition, growth rate is retarded to a certain extent.

Tobacco (Peralta and Paguirigan 1936) possesses the power of producing branch roots rapidly, shortly after pricking. In studies on the root development of tobacco plants the following were found:

> * * * The number of secondary roots increased from 7 to 11 and also branch roots of the second order appeared. This rapid growth happened within a period of 5 days. The length of the roots of the secondary roots ranged from 0.5 to 4.2 cm with a total length of 17.5 cm. Some of the roots ran rather horizontally outward, others obliquely downward, all into territory unoccupied by the primary root ramifying in a volume of soil 4 cm in diameter and 3.7 cm deep."

In spite of the inherent property of tobacco seedlings to produce roots rapidly after pricking, still the retarding effect of pricking upon the growth of tobacco seedlings was so great that pricked seedlings 28 days old required at least about seven weeks to fully overcome rapid uninterrupted growth of the unpricked plant. (Tables 1, 2, 3, and 4). But why did the rate of growth of unpricked seedlings lag behind after a period of 77 days on the seedbed? This behavior of leaf growth of the unpricked plants is explained to be due to two causes, namely, competition among the leaves for sunlight on the one hand, and competition among the roots for water and nutrient on the other.

The unpricked seedlings were sown at the rate of 0.10 gram per square meter. With this rate of seedling, 236 plants developed and spaced on the average of 6.5 cm apart. The pricked seedlings were set on the seedbed at 10 cm each way. Tobacco seedling, 64 days old was described by Peralta and Paguirigan (1936) as follows:

> The tip of the seventh leaf had appeared * * * with a leaf spread of 9 cm. The number of secondary roots increased from 12 to 16 and tertiary roots were abundantly produced ranging from a few millimeters to 1.5 cm in length. The bulk of the absorbing surface ramified in the first 4-centimeter layer of soil occupying a volume of soil 8.5 cm in diameter and 7.5 cm in depth. The total length of the root system averages 117.9 cm.

In the light of the above cited finding, it is obvious that during a period of 14 days, between the ages of 63 and 77 days (Tables 1, 2, 3, and 4), the leaves of the unpricked seedlings were overlapping each other. According to Weaver, 1929, shaded leaves can not do photosynthetic work. Therefore, there was a reduction in the rate of photosynthesis of the unpricked seedlings because only the unshaded leaves can do photosynthetic work. At the same time there was competition among the roots for water and nutrient. The roots of one plant after attaining the age of 63 days were already encroaching upon the domain of another plant for water and nutrient. This state of condition of the unpricked seedlings when the age of 64 days was reached resulted in a diminution in the growth rate of the tobacco plant. On the other hand, as the pricked seedlings were spaced 10 cm apart, the leaves at this period did not overlap each other. Most of the leaves, if not all, were able to do photosynthetic work. Likewise the roots were not yet competing for water and nutrient. These decided advantages of the pricked seedlings towards the later period of growth development made

it possible for the pricked plants to overcome the rapid growth rate of the unpricked seedlings upon reaching at least the age of 77 days.

Best size and age of planting material.—The results presented in Tables 5, 6, 7, and 8 and the graphs in Figure 1 conclusively show that the size of planting material is a very important factor to consider in the culture of tobacco plants. The seedlings transplanted young with leaves 4.2 cm long and 2.2 cm wide were not good planting materials. A very high percentage of death was observed a week after they were transplanted. Likewise, tobacco seedlings that were big and old and had developed leaves with a total leaf product (green leaves) of not less than 1,000 sq. cm were also poor planting materials (Table 5). Seedlings of this size were at least 70 to 80 days old.

Further examination of Tables 5, 6, 7, and 8 show that in general, the best planting materials (using per cent death-effect of transplanting as criterion) were seedlings, the lengths of the biggest leaf of which ranged from 10 to 18 cm. This size of planting material was obtained from seedlings with ages ranging from 51 to 65 days. The size of the leaves is very essential to consider especially when pruning of leaves is not practised during the time of transplanting, as done in many crop plants, in order to balance the destroyed roots during the process of transplanting. It is of interest to note, however, that the length of the biggest leaf of pricked seedlings 51 days old was less than 10 cm. Whereas, the lengths of the biggest leaf of unprickled seedlings were 10 cm or longer. The size was attained by pricked plants of the early maturing varieties, like Ilagan Sumatra, Samsoun Bafra, and North Carolina Bright Yellow, within 58 days and by pricked plants of the late maturing variety, like Simmaba within 65 days. There was, therefore, no advantage gained (as regards time) of pricking seedlings. On the other hand, it was an unnecessary operation in the growing of tobacco, especially when the culture is carried on extensively.

Effect of age and size of planting materials upon the growth rate and successive developments of tobacco plants.—Upon examination of the figures presented in Tables 5 and 9 and the graphs shown in Figure 2, the following facts were evident, thirty-two days after transplanting on the field: For the early maturing variety like Ilagan Sumatra, the most rapid growth rate

observed on the field was that of the unpricked planting materials, 51 days old, and, that of the pricked plants, 58-day-old seedlings. The average leaf product of the former increased from 127.0 sq. cm to 1359.9, and that of the latter from 202.5 sq. cm. to 2,067.9 (Figure 2). The percentage of growth in-

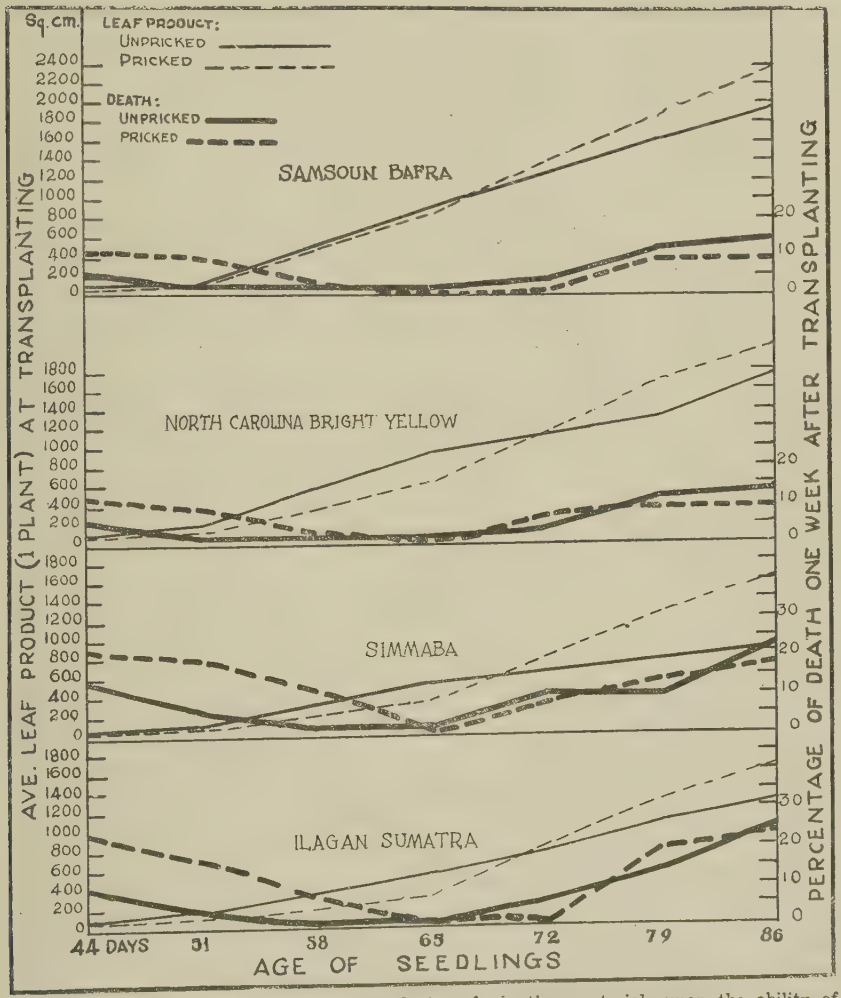

FIG. 1. Graphs showing effects of age and size of planting materials upon the ability of transplanted seedlings on the field to survive one week after transplanting.

crease was 971 for the unpricked and 921 for the pricked seedlings. For the late maturing variety like Simmaba, the 58-day-old pricked and unpricked planting materials showed the most rapid rate of growth.

The biggest developed plants, thirty-two days after the transplanting of the early and late unpricked maturing varieties, were the seedlings transplanted at the age of 65 days. The average total leaf product of the early maturing variety was 3,525.2 sq. cm and that of the late maturing variety was 5,147.9 sq. cm. The biggest plants of the transplanted pricked planting mate-

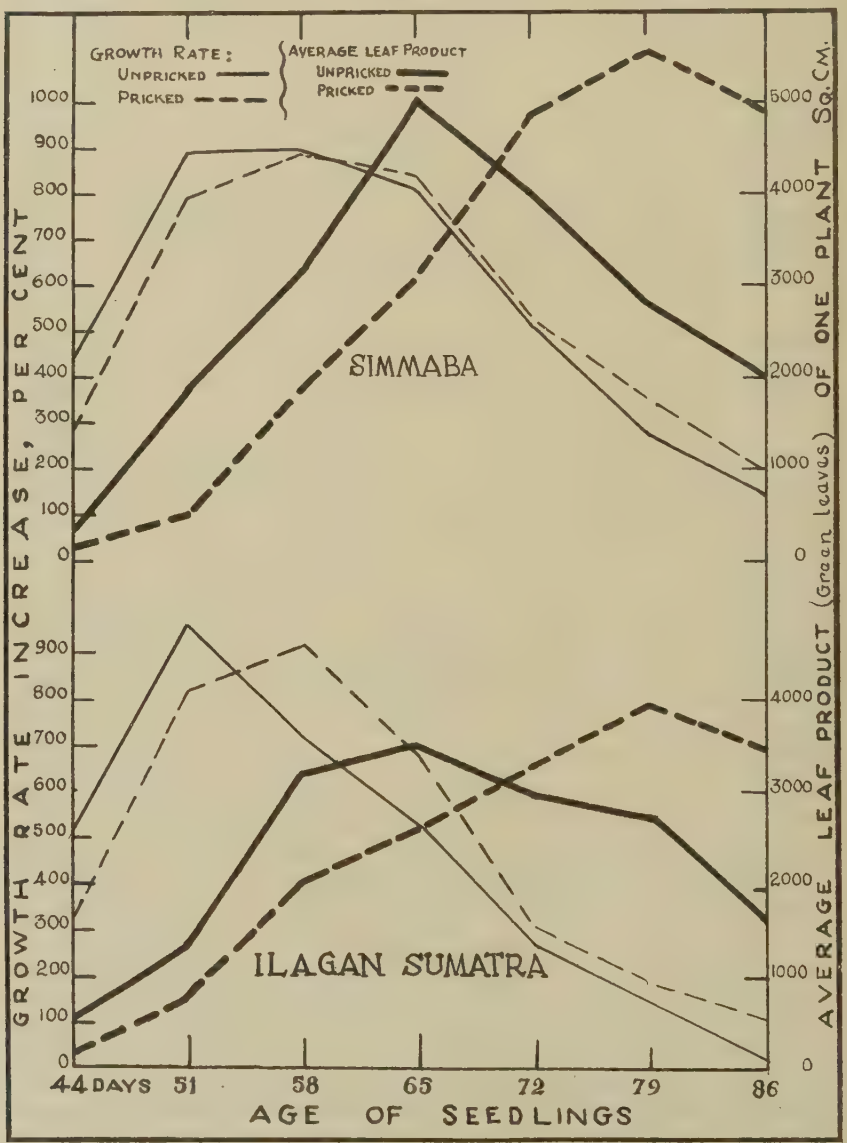

FIG. 2. Graphs showing effect of age of planting materials upon growth rate and stature of tobacco plants during the first 32 days on the field after transplanting.

rials after the same length of time were the 79-day-old seedlings (Figure 2).

When the tobacco plants reached full maturity (at the time of first priming), the most developed plants of the early maturing variety were the unpricked seedlings transplanted at the age of 51 days. The next biggest plants were the pricked seedlings transplanted when they were 58 days old. The biggest plants of the late maturing variety, like Simmaba, were those transplanted pricked and unpricked seedlings at the age of 58 days. Small plants were developed from seedlings transplanted at the ages of 44, 79, and 86 days (Figure 3).

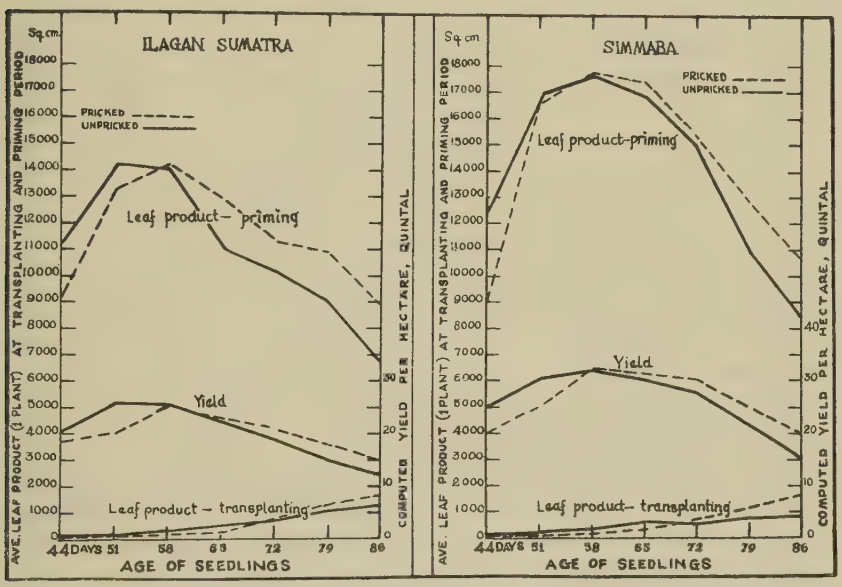

FIG. 3. Graphs showing effect of age and size of planting materials upon the final development and yield of tobacco plants.

In the present study under discussion, seedlings 44 days old from the date of sowing were transplanted. It was found out that the rate of growth was much slower than the growth rate of the 58-day-old seedlings. Of the early maturing varieties, like Ilagan Sumatra, seedlings transplanted less than 51 days old developed into small plants. Likewise, seedlings of the late maturing variety, like Simmaba less than 58 days old, also developed small plants.

Effect of age and size of planting material upon yield.—The age of planting material does not only modify the rate of growth of the plant, but also affects the yield. Table 11 shows

that when tobacco seedlings were transplanted at ages between 51 and 65 days, the highest yield possible was obtained. This fact was found true in all of the four varieties of tobacco tried.

Unpricked seedlings transplanted at the age of 79 days or older yielded less than seedlings transplanted at the age of 44 days. But pricked seedlings 79 days old or older produced a heavier yield than unpricked seedlings of the same age. On the other hand, unpricked 44 day-old-seedlings gave yield greater than pricked plants when transplanted at the age of 44 days.

Of the early maturing varieties like Ilagan Sumatra, North Carolina Bright Yellow, and Samsoun Bafra, the best yield was obtained from unpricked seedlings transplanted at the age of 51 days. But when the seedlings were pricked, the highest yield was obtained from seedlings transplanted when they were 58 days old. Comparing the two highest yields obtained from the unpricked and pricked seedlings, the produce from the transplanted unpricked 51-day-old seedlings were heavier (Table 11). Under this condition the results obtained corroborate the findings of Weaver and Clemente (1929), who state:

> Experiments have clearly shown that the general effect of transplanting is to retard growth, delay fruiting, and reduce yield. The degree of retardation varies with the kind of plant, its age, and the conditions of transplanting.

From the late maturing variety like Simmaba, the best yield was obtained from unpricked and pricked seedlings transplanted at ages between 58 and 65 days. This shows that a late maturing variety of tobacco takes longer time to develop seedlings to the best size of planting material on the seedbed than seedlings of early maturing ones, inasmuch as the latter only took 51 days. This difference of time is an important item to consider in the raising of tobacco. The crowding of time during transplanting period on the field can be avoided.

SUMMARY

1. The three types of tobacco, namely, the cigar-wrapper, the cigar-filler, and the cigarette-filler were grown in Los Baños Economic Garden, Los Baños, Laguna during the years 1935 and 1936.

2. Different ages of pricked and unpricked seedlings ranging from 44 to 86 days old from the date of sowing were used as planting materials. The pricked seedlings were spaced 10 cm

apart on the seedbed, and the unpricked seedlings were spaced, on the average, 6.5 cm apart on the seedbed. The rate of sowing was 0.10 gm per square meter.

3. A very high percentage of recovery was observed by transplanting on the field tobacco seedlings with leaves, the length of the biggest leaf of which was not less than 10 and more than 18 cm. To attain the minimum size, best for transplanting, the seedlings took 51 days to develop, when unpricked and 58 when seedlings.

4. The best size of planting materials was developed by unpricked seedlings within 51 days (for the early maturity varieties). Pricked seedlings at this age (51 days old) were found still below the average best size of planting materials. There was no advantage gained as regards time of pricking seedlings.

5. Under normal conditions, seeds of late maturing varieties, like Simmaba, required at least 58 days' time on the seedbed before the best size of planting materials could be developed.

6. Planting materials as old as 44 days or as old as 79 days did not develop to a big plant upon reaching maturity. The best stands of tobacco plants were obtained from seedlings transplanted at ages of between 51 and 65 days.

7. Of the early maturing varieties of tobacco, like Ilagan Sumatra, North Carolina Bright Yellow, and Samsoun Bafra, unpricked seedlings transplanted at the age of 51 days produced the heaviest yield. The pricked 58-day-old planting materials produced the second heaviest yield.

8. Of the pricked and unpricked seedlings of the late maturing variety, like Simmaba, the 58-day-old produced the highest yield. But seedlings of Simmaba variety transplanted at the age of 65 days produced yield higher than that of either the seedlings transplanted at the age of 45 days, or the seedlings transplanted at the age of 51 days.

9. When transplanting on the field was delayed (as late as 72 days), pricked planting materials produced yield better than that of unpricked plants.

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ILLUSTRATIONS

TEXT FIGURES

AROMATIC CIGARETTE LEAF TOBACCO CULTURE IN THE PHILIPPINES

(Farmers' Circular 16)

By Domingo B. Paguirigan
Chief, Tobacco Research Section
Bureau of Plant Industry, Manila

and

Jose C. Ramos
Assistant Agronomist
Bureau of Plant Industry, Manila

THREE PLATES

Choice of varieties (Plate 1, figs. 1 and 2; Plate 2).—In the order of their yields the varieties *North Carolina Bright Yellow, Adcock,* and *Orinoco* are recommended for the Virginia type and *Samsoun Bafra* for the Turkish type. Of the Virginia type, the *North Carolina Bright Yellow* has the brightest yellow leaves.

Soil requirements.—Cigarette tobacco has been successfully grown in soil ranging from heavy clay loam to sandy loam of normal fertility. The *Samsoun Bafra,* however, should never be grown in rich land.

Climatic requirements.—The best quality of cigarette leaf tobacco has been produced by sun-curing in regions with well-defined dry and wet seasons, like the Ilocos provinces and Central Luzon. In regions like the Cagayan Valley, where the dry period lasts from one to three months only, cigarette leaf tobacco has also been successfully produced with the use of the rather expensive flue-curing barn.

The optimum seasonal periods of field operations for sun-cured cigarette tobacco are as follows:

Sowing of seeds	September 15 to October 15
Transplanting	November 1 to December 15
First harvest (priming)	January to February
No. of days required to cure leaves under the sun	12–24
No. of harvests	4–15
Intervals between harvests	10–12 days
Last harvest (till beginning of rainy season)	May

Location and Preparation of seedbeds.—That portion of the field near a good water supply where rain water does not stagnate should be selected for the seedbeds.

In the early part of September, the land is plowed and harrowed until the soil becomes thoroughly pulverized. Then the plot is divided into beds, 1.2 meters wide and 10 meters long. The beds should be separated from each other by paths dug out to a depth of about 10 cm, and the soil should be placed over the beds, thus raising them. The low paths will serve as drainage canals. Each seedbed is provided with portable abacá cloth, nipa, or cogon sheds to protect the seedlings from the rain and intense heat of the sun. The east side of the shed should be raised to about a meter high and the west side to about 75 cm. from the ground, in order that the seedlings may receive the mellow heat of the morning sun but not the strong afternoon sun.

The final preparation of the seedbeds consists in working the soil with hand tools until the particles become pulverized.

Sowing of seed.—Before sowing the seed it is always advisable to test the percentage of germination. The simplest method is to place 100 seeds between two pieces of blotting paper on a clay plate with a cover to fit, and then keep the blotting papers moist for one week, when the percentage of germination can be determined by counting the number of seeds which have germinated. Five or six grams of seeds with a percentage of germination ranging from 70 to 100 per cent will be a sufficient quantity to sow in one bed that measures 1.2 by 10 meters. Before the seed is sown, the beds should be sterilized by pouring boiling water over them. The uniform distribution of seed in the bed is insured by mixing it with about 10 parts of wood ash or fine sand before sowing.

Each seedbed of the size mentioned above will produce not less than 1,000 good seedlings. In this system about 20 beds will be required for every hectare. It is always practical to sow extra beds after two weeks as a precaution against adverse conditions.

When there are many red ants in the seedbeds there is always danger of the seeds being carried away by them. To prevent this, it is a good plan to scatter corn meal made into a mash with sugar along the borders of every seedbed. The bait will keep the ants away from the seeds.

It is a general practice among farmers to wrap the tobacco seeds in a piece of cloth and soak them in water for about 48

hours before sowing them in the seedbeds in order to insure germination. Incidentally, ants do not carry the seeds away once they have germinated.

Care of Seedlings.—The soil in the seedbeds should be kept moist all the time. Weeds of any kind should be pulled out as they appear. If the seedlings are attacked by damping-off diseases, all the infected ones including the few healthy ones around the infected area should be removed together with the soil. Treating the infected area with 5 per cent formaline solution will minimize further infection.

Crowded areas in the seedbeds should be thinned so that the remaining seedlings should be about 4 cm apart.

About two weeks before transplanting, the sheds of the beds are removed to expose the seedlings to the sun to make them strong.

Preparation of the field.—If thick grass is growing in the field, it must be cut down and burned. The land should be plowed and harrowed at least two times or until the soil becomes well pulverized. One or two days before planting, furrows are to be made in the field 80 cm apart. The native plow is appropriate for this purpose.

Planting.—The seedlings are ready for planting at the age of about six weeks. Before pulling them up the beds should be watered thoroughly to make the soil soft, thereby minimizing the breakage of the root systems of the plants. Only healthy and vigorous seedlings are to be selected for planting. With a trowel, holes of sufficient depth are made along the furrows, 70 cm apart for the Virginia varieties and 50 cm for the Turkish varieties. In setting the seedlings in the holes one must be careful not to bend the roots as this arrests normal development. The earth around the base of the plants should be pressed down gently with the fingers in order to make the plants stand firm in the soil. A week later all dead seedlings should be replaced.

Cultivation.—As soon as the plants are well established in the soil, the first cultivation is done by passing the plow twice between the rows. Cultivation is repeated at regular intervals of two weeks until the plants are big enough.

Control of pests and diseases.—Of all the insect enemies of the tobacco plant, the cutworms are the most destructive. Control is effected by dusting the plants with calcium arsenate. It is prepared by mixing one part commercial calcium arsenate pow-

der with 16 parts of sterilized road dust. A bamboo tube with a node at one end and the other end covered with cheesecloth or fine mesh wire will make a cheap and practical duster. The dust is applied to each individual plant by shaking the tube to make the powder pass through the cheesecloth or wire until the top leaves are sufficiently covered with a thin layer of the mixture. Occasional hand picking insures the perfect control of the worms.

The safest guide to follow in controlling fungus diseases is to practice sanitation even to the extent of pulling up all the plants showing a diseased condition, especially those attacked by mosaic and wilt diseases. It is better to destroy a few plants rather than let the disease spread in the field.

Topping.—Topping should not be done, as a rule, unless the plants are extremely under-developed, as this tends to produce leaves that are too coarse. In cigarette tobacco the aim is to produce leaves with a medium body, so that if topping is practised at all, only the flower buds are pinched off as they appear.

Seed selection.—The seed for subsequent planting should be taken only from healthy and vigorous plants. The plantation should be gone over thoroughly when the crop is about to flower and the most ideal and vigorous plants are selected. To keep the seeds pure, the entire flower head of each individual plant should be covered with Manila paper bags before the flowers open and until the seed pods are fully developed. When the capsules are mature, they are cut off from the stem of the mother plant, and are hung inside the shed for thorough drying. The capsules are then hulled, and the seeds are stored in air-tight containers. The seeds, if stored properly, will remain viable for at least two years.

Harvesting.—Some of the leaves begin to mature in about 6 to 8 weeks from the time of transplanting. The leaves can be harvested by priming or picking them one by one as they become mature. Immature as well as over-ripe leaves should not be harvested. Change of color from dark green to light green is a good index of maturity.

Stringing and poling.—As soon as the leaves are gathered from the field, they should immediately be taken into the shed and then sorted according to size and soundness. Broken and worm-eaten leaves should be further separated.

Stringing is done by passing the needle with twine or string through the petiole of the leaves. About 100 leaves are ar-

ranged, preferably face-to-face and back-to-back and about 1 cm apart on the string. Each end of the string is attached to a pole of practically the same length as the string and about 2 to 4 cm in diameter.

Native sticks can also be used, provided the leaves are stuck just as described.

Sun-curing.—The poled or stacked leaves are to be hung on racks outside in the sun until they become thoroughly dry. But portable covers should be ready in case of rain or dew.

Flue-curing.—In regions like the Cagayan Valley, where sun-curing is not practicable owing to uncertain weather conditions or to the short dry period, flue-curing has to be resorted to. This method of curing necessitates the construction of a hermetically tight barn, heated gradually by a system of flues to a maximum of 66° C.

Preparation of product for the market.—When the leaves are thoroughly cured, they are removed from the poles or sticks and placed in bundles of 25 (more or less) each. The number of leaves in each bundle need not be exact inasmuch as they are sold by weight. A leaf should be used for tying a bundle, because this is convenient, not only for the manufacturer who must cut the whole hand, but also for the grower who is thus saved the cost of the tying material.

The bundles or hands should then be packed in receptacles, and suitable weights should be placed over the piles, not only to prevent the penetration of harmful nicotine, but also at the same time, to conserve the much-desired volatile aroma of the leaves.

ILLUSTRATIONS

Plate 1

Fig. 1. An ideal plant of the North Carolina Bright Yellow, one of the best variety adaptable under Philippine condition for the production of aromatic cigarette leaf tobacco.

2. An ideal plant of the Samsoun Bafra variety, a Turkish type acclimatized for the production of aromatic leaves used for blending in the manufacture of American-style cigarette.

Plate 2

Fig. 1. A partial view of Virginia tobacco plantation of the Cresana variety in the hacienda of Samson Hermanos Co., Inc.

2. Another view of a Virginia tobacco plantation of the Adcock variety in the hacienda of Samson Hermanos Co., Inc.

Plate 3

Fig. 1. A modern flue-curing barn for the curing of Virginia and Turkish tobacco, Central Experiment Station, Bureau of Plant Industry, Manila.

2. Interior view of a miniature flue-curing barn showing the arrangement of the heating system and the method of hanging the leaves to be cured.

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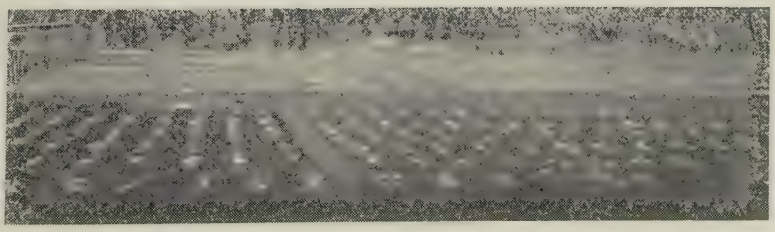

3

PLATE 1

1

2

PLATE 2

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2

PLATE 3

THE CULTURE OF COFFEE

(Farmers' Circular 4)

By F. G. Galang
Of the Horticulture Section
Bureau of Plant Industry, Manila

TWO PLATES

At present the per capita consumption of coffee in the Philippines is very low—0.23 kilo against 5.6 kilos for the United States, 6.9 kilos for Norway, and 7.0 kilos for Sweden, the three greatest coffee-consuming countries of the world. That for Great Britain and Ireland amounts to only about 0.4 kilo a year, but even this small amount is greater than that of the Philippines. Yet, the annual importation of coffee into the Islands amounts to over a million and a half pesos. A revival of the once flourishing coffee industry of the Philippines will greatly reduce this importation or stop it altogether.

COFFEE VARIETIES AND THEIR REQUIREMENTS

Many farmers in this country often commit the mistake of planting coffee varieties in localities not well suited to their growth. It ought to be remembered that a given variety of coffee will only succeed when cultivated at proper altitudes and in a district with proper rainfall. In other places where the environment is not favorable, it may also grow if given extraordinary care, but it cannot be raised profitably on a commercial scale. To avoid unnecessary losses of plants and time, only those varieties which are adapted to our soil and climate should be grown.

The principal types of coffee are the Arabian, the Robusta, and the Liberian.

The Arabian type, which includes the Porto Rican, Padang, Bourbon, Erecta, Columnaris, Maragopipe, San Ramon, Mocha, Kona, and Murta, is found to grow well at lower altitudes with a well-marked short, dry season, but because of the coffee blight, *Hemileia vastatrix*, it should not be planted at altitudes below 800 meters; it thrives best from 2,000 meters up. In the

Mountain Province, the Arabian coffee is attacked by the blight if planted below 1,000 meters elevation. At and above this elevation, the climate is so favorable for the growth of the plant that when kept in good condition it is sufficiently capable of resisting the attack of the blight to yield a profitable crop. Altitude alone, however, does not render this type resistant to blight. Soil and rainfall play important part. It grows best on a rich friable, even rather stiff loamy soil.

The Robusta, with its allied types, Congo, Uganda, Quillou, Canephora, Buckobensis, Sankurensis, and Laurensis, should be planted only in a rich, friable, and well-drained loamy soil and where there is a well-distributed rainfall throughout the year—preferably from 2,000 to 2,500 mm. It is very sensitive to soil acidity. It requires an altitude of from 450 to 750 meters for its best development, although it may be grown from sea level to an elevation of 1,000 meters, and it will not thrive well at altitudes higher than 1,000 meters. It is very susceptible to wind and suffers especially from continuous dry winds. The crop is almost continuous in districts having a well-distributed rainfall. Generally speaking, the coconut and abacá districts of the Philippines are better adapted to the culture of this type if rainfall is to be considered alone.

The Liberian type, which includes the Liberian, Excelsa, Abeocuta, Dybowskii, Dewevrei, and Arnoldiana, requires an elevation of from sea level to 700 meters. But the Liberian variety should not be planted above 350 meters. This type of coffee is drought-resistant, and it succeeds in districts with a pronounced dry season and a rainfall of 1,200 mm. The yields will be greater, however, in places where there is a uniform distribution of rainfall. It thrives even on a heavy clay soil, and from well-drained peaty soils, fairly good crops have been obtained. This group can be grown with or without shade, whereas the Arabian coffee requires shade.

The hybrids, Kawisari B and D, are becoming very popular varieties in Java because of their resistance to the blight and their excellent flavor. They are the natural hybrids of the Liberian and the Arabian coffees. These hybrids can withstand moderate drought, and with heavy rains they grow equally well, that is, they succeed under the same conditions as the Liberian and the Robusta types. The Kawisari B does best at altitudes of about 350 meters, and Kawisari D does best below this elevation.

It should be borne in mind that the rainfall in many parts of the Philippines is rather local. For instance, in the same

province there exists two or more seasons as regards rainfall. Furthermore, the effect of too little and too much rain in the development of coffee plants should be considered. In a marked dry season, the growth is checked, but this is usually followed by an excellent crop. The lack of soil moisture causes crop failures of coffee in spite of the normal courses of pollination. Where coffee is planted in places with marked dry periods coinciding with the blooming period, irrigation would be a good insurance for the regular and normal setting of the coffee berries. On the other hand, if the moisture is excessive, there is a tendency for the coffee plant to produce many leaves and few berries, and if there is too much rain, the flowers will rot and fall without setting fruits, and are also apt to be improperly cross-fertilized. However, coffee needs only a few hours of sunshine for a complete fertilization of its flowers. Heavy rainfall is not injurious to coffee, provided the soil is well drained, and it does not rain during the fertilization of the flowers.

Coffee suffers severely from strong winds, so wind breaks should be provided against the direction of the prevailing winds when natural windbreaks are absent.

The best temperature for coffee is from 60–75° F., and varying altitudes and rainfall are suitable according to the varieties, or types, of coffee.

PLANTING

In the nursery.—The seeds for planting should be carefully selected and only the best, full-grown, and well-shaped beans should be planted, preferably those obtained from mature, vigorous, and productive trees in the plantation. The seeds for planting should never be allowed to pass through the pulping machine, but instead, the husks should be removed by men, women, or children. The beans are then washed in fresh water with sand or ashes to avoid fermentation, then air-dried, and afterwards sown in seedbeds or preserved in moist charcoal, moss, or sand placed in air-tight containers.

The land having rich, loamy soil intended for seedbed and nursery should be well drained. With ordinary rainfall, a light bamboo frame should be erected above the nursery about 2.5 meters high or lower, and covered with split bamboo, cogon, or other grasses or palm leaves to provide half shade. If the rains are so heavy that they are likely to wash out the coffee seeds, they should be sown under a rain-proof shelter. The land should be spaded thoroughly to a depth of about 30 cm and

all stones, roots, and trash removed. From 1 to 1.5 meters is a convenient width for seed and plant beds. The beds should be about 10 cm or so higher than the general level of the ground because of the danger of flooding during heavy rains.

Provided that the seedlings can be properly transplanted to the nursery beds after germination, the coffee seeds may be sown broadcast at the rate of 2,000 to 2,500 seeds to the square meter, but if the transplanting cannot be promptly attended to, it is best to spread the seeds over an area twice as large in order to produce strong plants. The seeds should be covered with not more than one cm of earth, and then watered thoroughly. Unless the rains provide sufficient moisture, the seedbed should be well-watered from time to time whenever the soil appears dry. Frequent sprinkling, but not enough for the water to penetrate more than a few mm below the surface of the soil, is harmful rather than beneficial both in the seedbed and in the nursery, for this encourages a shallow root system.

As soon as the first pair of leaves are fully expanded, the seedlings should be transplanted to the nursery beds, which should be prepared like the seedbeds. If the land is poor, it is well to spade in a liberal quantity of well-decayed manure or compost. The plants should be taken up carefully, the injured tap roots nipped off before transplanting with the aid of a pointed stick or small dibber, spacing them from 15 to 20 cm apart each way. In doing this, great care should be exercised to make the holes sufficiently wide and deep, so that the roots are pointed downward and not doubled up in the hole; that the soil is well packed around them and that the plants are not set out deeper than when in the seedbed. More plants should never be removed at one time from the seedbed than what can be conveniently transplanted before they show signs of wilting, and the plants dug up should not be left exposed until the roots dry out. The plants should be thoroughly watered before and after transplanting, and the beds, kept from weeds and watered as often as necessary.

In the field.—Land overgrown with trees and shrubs should be cleared, the vegetation cut and burned during the driest period of the year, and the small stumps grubbed and burned together with the remaining logs. After this is done, the land is ready for staking and planting. Cogon land must be plowed and crossplowed and planted to legumes a year in advance of the planting of the coffee in order to destroy the cogon and im-

prove the soil. By this method, the plantation can be cultivated by animals and the cost of weeding is greatly lessened or reduced. The holes are dug from 80 to 100 cm deep and 40 to 60 cm in diameter, the size of the holes depending of course upon the character of the soil and the size of the plants to be transplanted. On light soil the holes can be dug smaller than on a heavy soil.

Where the land is slopping and the texture of the soil is of such a nature that it is easily washed away by rains, terracing should be done before planting the coffee. Trees in such areas will suffer from diseases and the yield fall off considerably. The terraces should follow the contour of the land, and should be so arranged as to hold the rain water and prevent soil wash. The lack of drains has been the cause of the rapid decline of many plantations in the Islands; therefore, the construction of ditches for draining off the extra water must also be undertaken wherever and whenever necessary.

Small seedlings having 5 to 6 pairs of leaves can be transplanted with or without a ball of earth with equally good results, but if larger seedlings are to be transplanted, it is advisable to provide each with a ball of earth in order to prevent a setback of the plants due to disturbance of the roots. About one-half of the foliage should be cut, and a trench dug at the end of the nursery bed to a depth of about 20 cm or more, depending upon the development of the roots. Then a thin, sharp bolo or spade should be passed through the soil underneath and around the plants, neatly severing all straggling roots and leaving the plant in the center of an oblong ball of earth. If the soil is so loose that it falls away from the roots when the plant is removed from the nursery, great care should be taken not to allow the roots to dry out and to set out the plant so that the roots will not be matted together in the center of the hole, but spread out in their natural position. The holes should be filled only with surface soil. In the course of planting, the soil should be worked in, and firmly packed about the roots, and the plant set out in the field at the same depth as in the nursery. Due care should be taken not to break the ball. Transplanting should be done preferably at the beginning of the rainy season to enable the seedlings to become rooted before the dry season. Young plants should on no account be transplanted during the dry weather unless irrigated, as a few days' hot sun will be fatal to them.

Spacing should be given careful consideration. If too close, the plants become crowded and the lower branches, deprived of sunlight, will shed their leaves and fall; if the distance is greater, the shade of the plants would not be sufficient to decrease soil erosion and evaporation of moisture. The distance and the number of plants to the hectare required for the different coffee varieties are as follows:

Variety	Distance in meter	Number of plants per hectare
Abeocuta	3.5–4.0	625– 816
Arabian	2.5–3.0	1,111–1,600
Canephora	2.5–3.0	1,111–1,600
Congo	2.5–3.0	1,111–1,600
Excelsa	4.0–4.5	493– 625
Dybowskii	4.0–4.5	493– 625
Liberian	3.5–4.0	625– 816
Mocha	2.5–2.5	1,600–1,600
Quillou	3.0–3.5	816–1,111
Robusta	3.0–3.5	816–1,111
Uganda	2.5–3.0	1,111–1,600

Shade.—The amount of shade to be provided in a coffee plantation depends upon the altitude. Less shade is needed where the sky is frequently overcast than where it is clear. As a rule coffee is shaded most heavily at the lowest elevation where it is grown, the need for shade decreasing with the rise in altitude. Opinions vary as to the best and most suitable tree for coffee shade. A particularly good shade in one locality may not prove so in another district. Trees that do not grow so large with a maximum spread of branches to shade a large area, fine leaves and not deciduous, are preferable for coffee shade wherever they grow. Besides, they should be subsoil feeders, capable of enriching the soil, not susceptible to diseases and pests attacking coffee, capable of standing against strong winds, quick growing, long-lived, with a big leaf fall, and suitable to the soil and climatic conditions of the place.

While it seems probable that ipil-ipil will be equally good for coffee shade in the Philippines as in Java, judging from the result obtained at Lamao, Bataan, still there may be exceptions to this rule. In Bukidnon and Basilan, Mindanao, for instance, the dapdap appears to be better than the ipil-ipil; in Lanao, Mindanao, the silk-oak and the dapdap appear to be desirable; while in Batangas, the madre-cacao is being commonly used.

Shade trees should be planted in advance so as to provide the proper shade at the proper time. If not, and the perma-

nent shade trees are not large enough to provide sufficient shade, a temporary shade should be planted at the same time the coffee seedlings are set out in the field. Cadios, castor bean and *Tephrosia* which are easily eradicated, are not likely to become weeds, and produce growths of leaves, for mulch makes excellent temporary shades for coffee.

It is always advisable to plant shade trees rather closely, and then gradually cut away the surplus branches, then the trees, leaving at the final thinning only one shade tree for every four coffee plants. If the permanent shade trees are allowed to develop too thickly and with too heavy branches, the coffee plants will grow tall with few and weak branches, longer internodes, and fewer berries, for too much or too little shade means reduced crop. Also dampness favors the development of fungi. After the elimination of all the unnecessary shade trees the branches of the permanent ones should be pruned off whenever necessary. Pruning should be done on every other row.

The easiest way of setting out ipil-ipil for shade tree is by cuttings obtained from the tops of old ipil-ipil trees, by inserting them in holes made with a crowbar during the rainy season, and by packing the soil well around them so that they remain firm in the ground. Dapdap or madre-cacao cuttings may be treated in the same way as the ipil-ipil.

If the shade trees are propagated from seeds, prepare a seedbed, sow and cover the seeds thinly with fine soil in rows from 20 to 25 cm apart. When the plants are needed for planting and cut them back to a height of about a meter and transplant them as in the case of the cuttings. Seeds can also be planted directly, if so desired.

CARE OF PLANTATION

Cultivation.—The land should be kept free from weeds with a cultivator, by hand-hoeing, or by cover-cropping. Cultivation should be done preferably a few days after the rains so as to conserve as much moisture as possible. Care should be taken so as not to injure the roots and branches while cultivating the open spaces between the coffee plants. When the coffee and shade plants are fully developed, only occasional hoeing is necessary.

Except where the land is exceptionally rich, it will be found advantageous to plant the vacant spaces between the coffee trees with some legumes for the first four years or until the

land is well shaded by the coffee and shade trees. This, if carried out properly, will minimize the cost of weeding, prevent soil erosion, and the rapid evaporation of soil moisture, and, if leguminous crops are planted, will enrich the soil.

In Java, ipil-ipil is planted on the edges and exposed places of the plantation, and in some cases, on steep land, ipil-ipil seeds are sown in a semicircular form in front of the coffee trees toward the bottom of the hill to prevent soil wash, and the ipil-ipil is continuously cut down to not more than two feet high. All the cut and dead branches are buried in the ground for green manuring.

Pruning.—If coffee trees are allowed to grow tall without topping, the harvesting and the treatment for diseases and pests will be very difficult, and they are also very liable to be blown down by strong winds. Furthermore, untopped trees have the peculiar habit of growing their branches near the ground and at the top, of leaving their middle bare or nearly so. This decreases the productivity of the plant. Top the plants when they are from 3 to 4 meters high and keep them at this height and allow no more than three stems to sprout from the ground by removing all superfluous shoots. This is to be done while the sprouts are still young, for at this stage they can be easily broken. All wild or water sprouts should be removed immediately so that long and spreading branches may be produced and the trees may be more fruitful. Unpruned trees cannot possibly yield a very profitable crop, and it is almost impossible to restore them at once. To induce the growth of more lateral branches, topping should be performed while the plant is still young or when it has made a growth of about a meter high.

Pruning, in order to be of benefit, should be done immediately after harvesting the crop, and should be finished before the flowering season. In pruning, clean cuts should always be made so that healing may take place at once, and all wounds should be painted with white lead or coal tar after the pruning has been performed to prevent the invasion of insects and fungi.

Conservation of soil fertility.—By proper crop rotation the fertility of the soil is more or less conserved. Coffee is a voracious nitrogen feeder, and therefore, this element should be given first consideration. The addition of nitrogen to the soil is done either by planting cover crops and plowing these under when fully matured or by adding artificial manures or fertilizers.

Various fertilizer mixtures have been reported to have given good results for coffee in other countries, but in the Philippines this result is problematical and should first be given a fair trial.

Control of pests and diseases.—There are several diseases and pests which attack the roots, stem, branches, leaves, flowers, and berries of coffee, but none of them has so far become serious in the Philippines except the blight and a root rot. The first one is so well known here that there is no need for its description. A remedial measure for blight has been worked out, but found very expensive in field practice. The root rot generally appears at the close of the rainy season in poorly drained land. During its early stage it can be controlled by disinfecting the injured portion with 4 per cent formalin solution. The first symptom of this disease is the yellowing of the leaves.

The mealy bug are sometimes very injurious to coffee flowers, but can easily be eradicated by spraying them with soap-sud solution.

Rejuvenation.—Considerable variations have been found in coffee, grown from seeds, and it is becoming generally recognized that budding and grafting from individual superior trees must be resorted to in order to obtain the best results. In the case of the hybrids, this operation is in fact absolutely necessary, since all the hybrids that have fruited so far in Java failed to come out true to type and produced exceedingly variable progeny, which in most cases was inferior to the hybrid parent.

In rejuvenating the old and unproductive coffee trees, manuring, cover-cropping, top-working, thinning, and planting of shade trees should be done, as the case may require. The old as well as the young unproductive trees may be made to bear fruits by top-working. This saves the expenses of planting news ones, and the trees so treated produce a crop within a shorter time. This method is as follows:

The trees should be lopped at a height of about 25 cm above the ground, as are the newly budded trees in the nursery. Numerous sprouts are soon produced from the stump. As soon as these sprouts are about 30 cm tall, the lopped part may be entirely severed from the stump and removed. Only two of the numerous suckers should be allowed to develop for grafting or budding with scions taken from a known productive tree. When the two newly grafted branches are well under way, cut off the poorest and leave only one to grow into a tree. Budding

or grafting the top-worked tree is performed in the same way as on young seedling stocks in the nursery except that the scions should be taken from the terminal branches only, for if budded or grafted with a horizontal scion, the resulting plant always develops into a low-spreading bush, and never produces vertical growth. Care should be taken to remove the wild or water sprouts as they appear.

HARVESTING AND PREPARATION

Picking the ripe berries from the nodes is done very roughly in the Philippines. No precaution is being taken not to injure the nodes, regardless of the fact that these parts are the permanent fruiting places of the coffee plants. Needless to say, this method of picking coffee berries should not be used. Avoid pulling the berries against their natural direction. They should always be pulled toward the outer end of the branches so as not to bruise any of the nodes. If this is not done, the productive capacity of the plant will be lessened as the plant gets old.

A clean and uniform product that will bring a good price is obtained by harvesting only the ripe berries.

In a crude way many planters still prepare coffee as follows:

1. The ripe berries with husks on are dried in the sun and husks, pulp, slime, hull, and part of the silverskin are removed by handmills or mortars and pestles or with the aid of a rice mill. This system of removing the silverskin can easily be done with Arabian coffee, but with the other kinds of coffee, like the Liberian and the Robusta types, the removal of the silverskin by this process is rather difficult. Pulping the fresh berries is now being facilitated by the use of a wooden roller devised at the Lamao Experiment Station.

2. The berries are first fermented for 24 hours, and after that, they are washed and dried in the sun until the inner skin separates readily when crushed or pounded in a wooden mortar. This method of drying requires much labor especially during the rainy season.

3. In preparing coffee on small scale, the red coating is peeled off, and then the berries are carefully washed. After this they are dried in the sun for 4 to 5 days or until they are ready to be crushed. When dried they are spread on flat boards, and a small wooden roller is rolled over them, thus breaking the second coating.

In Brazil, coffee is prepared in two ways; namely, by the dry and the wet systems. The dry method consists of spreading the

berries in the sun and protecting them from rains, and when they are dried, they are stored in dry places where the pulp is separated. By the wet method, the berries are submerged in a tank of water for several days; then the pulp is removed by trampling and dried afterwards.

If the berries of the Liberian and the Robusta types are prepared by the aforementioned systems, after they are sun-dried the silverskin can be removed by moistening the beans and redrying them, then passing them through a hand rice mill or other suitable machine. If all the silverskin is not yet removed, the operation is to be repeated a second or third time. The silverskin of the sun-dried berries is very difficult to remove because, it is not loose unlike the hot air-dried berries where quick drying is done.

In factory practice, coffee is prepared as follows: After picking, the leaves, stones, dirt, and other impurities are removed. They are next washed in channels filled with water, and then brought to the pulping machine for pulp removal. The beans are then fermented in vats of water or in heaps for several days. The slimy substance is removed after fermenting the beans by washing. After washing, the berries are drained on galvanized iron plate, perforated with circular holes, and then dried as quickly as possible. But in order to command a good price in the world market, the Robusta and the Liberian types require artificial drying in especially constructed dryers. To remove the silverskin the dried beans are passed to a huller as many as two or three times.

LIST OF ILLUSTRATIONS

PLATE 1

BUREAU OF PLANT INDUSTRY

AGRICULTURAL STATIONS

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2. Lamao Horticultural Station, Limay, Bataan
3. Lipa Coffee-Citrus Station, Lipa, Batangas
4. Tanauan Citrus Station, Tanauan, Batangas
5. Granja Sugar-Cane Station, La Granja, Occidental Negros
6. Gandara Seed Farm, Gandara, Samar
7. Baguio Plant Industry Experiment Station, Baguio
8. Maligaya Rice Station, Muñoz, Nueva Ecija
9. Ilagan Tobacco Station, Ilagan, Isabela
10. Maridagao Rubber Station, Pikit, Cotabato
11. La Paz Propagation Station, La Paz, Iloilo
12. Los Baños Economic Garden, Los Baños, Laguna
13. Sta. Maria Propagation Station, Sta. Maria, Ilocos Sur

SUBSTATIONS

1. Davao Seed Farm, Davao Penal Colony, Davao
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